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REPORT

BIOLOGICAL ASSESSMENT OF THE LITTLE VERMILION RIVER ADJACENT TO MATTHIESSEN AND HEGELER ZINC COMPANY

LaSALLE, ILLINOIS

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

A biological assessment of portions of the Little Vermilion River (of the Illinois River Basin) was conducted to support on-going Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities pursuant to the Administrative Settlement Agreement and Order on Consent for Remedial Investigation (RI)/Feasibility Study (FS) between the U. S. Environmental Protection Agency (U.S. EPA) Region V, Carus Corporation, and Carus Chemical Company in relation to the Matthiessen and Hegeler Zinc Company Site (Site) located in LaSalle, Illinois (Figure 1-1). In the context of the CERCLA investigations, the Little Vermilion River (LVR) along the Site is designated as part of Operable Unit 1 (OU1).

Given the nature of historical activities at the Matthiessen and Hegeler Zinc Company Site and the presence of slag material along the banks of and within the LVR in this area, there was interest in evaluating the ecological health of the aquatic community within this segment of the river. In particular, such information was needed to help inform the ecological risk assessment being conducted for OU1 under the CERCLA regulatory framework by providing information and lines of evidence related to the status of the aquatic community in the river for consideration as a component of the weight-of-evidence approach to ecological risk assessment. Therefore, a biological assessment was conducted to describe and evaluate the condition of aquatic communities in the LVR in proximity to the Site to inform remedial action decisions, specific to areas along and within the river. The aquatic community bioassessment consisted of four major tasks, including the evaluation of aquatic habitats, fish community surveys, benthic macroinvertebrate surveys (including mussels), and tissue analyses of aquatic organisms within the study area. Results of the fish and benthic macroinvertebrate surveys were then evaluated using indices of biotic integrity (IBIs) as described further in the next section.

The Illinois Environmental Protection Agency (IEPA) considers (along with other factors) the fish community IBI (fIBI) in conjunction with a macroinvertebrate IBI (mIBI) in making assessments of designated use attainment in streams pursuant to the Clean Water Act. If the mIBI is unavailable, the fIBI may be considered along with the Macroinvertebrate Biotic Index (MBI), which is a component of the mIBI, in making preliminary use attainment assessments. In that regulatory context, if a stream attains an fIBI score of $\geq$41 combined with an mIBI score of $\geq$41.8 (or a MBI score $\leq$ 5.9, if the mIBI is unavailable), the stream would be given a preliminary assessment that it is “Fully Supporting” of aquatic life use in Illinois streams. Under the Clean Water Act, IEPA equates the “Fully Supporting” terminology to a conclusion that a stream has “No Impairment” and is indicative of good resource quality (IEPA, 2008a). While this bioassessment was undertaken in a different regulatory context (i.e., as part of a CERCLA site baseline ecological risk assessment [BERA]), comparison of these values derived from the Clean Water Act to IBI scores for the river reaches sampled for this assessment provides a line of evidence of the overall ecological health of the aquatic community in the LVR.

The biotic integrity indices and other measures of aquatic community structure were also used to evaluate the condition of the aquatic community along areas of the Site relative to a within stream/same-stream reference river reach located upstream in the LVR and away from any potential impacts of the Site. In this manner, potential impacts to the aquatic community from the Site might be differentiated from larger scale watershed effects.

The results of all these analyses, undertaken as part of the bioassessment, contribute information and lines of evidence for consideration in the context of the weight-of-evidence evaluation, which defines the scientific burden for this project in accordance with U.S. EPA ecological risk assessment guidance (U.S. EPA, 1997). The full weight-of-evidence evaluation is contained in Section 4.1 (Baseline Ecological Risk Assessment LVR (OU1)) of Appendix RA (Risk Assessment) of the RI Report for the Site.

The report sections that follow present the field and analytical methods used to conduct the biological assessment of the LVR and associated findings and conclusions.

2.0 METHODS

The biological assessment of the LVR at the Matthiessen and Hegeler Zinc Company Site generally followed the methodology outlined in the Site Field Sampling Plan Addendum No. 1 (FSP, see Appendix A of this report), which was approved by U.S. EPA and IEPA on 4 May 2009. The assessment of the LVR fish and aquatic macroinvertebrate communities in the FSP was patterned after Illinois water and natural resource agency bioassessment protocols (IDNR, 2001; IEPA, 2007), which employ multi-metric index of biotic integrity (IBI) scoring systems to evaluate stream health. The Illinois protocols for assessing stream health using fish community data are based on Illinois Department of Natural Resources (IDNR) sampling protocol and IEPA fIBI guidance; the protocols for assessing stream health using macroinvertebrate community data are based on IEPA mIBI guidance. For the current study, certain components of the Illinois protocols were modified in consideration of site-specific conditions and objectives, and based on best professional judgment. Protocol modifications and the potential impacts to the results/interpretation of the biological assessment are discussed herein.

According to Illinois IBI protocols individual measurements of biological community attributes (i.e., metric values) are scored to yield a total IBI score. Resultant metric values convey the status of stream "health" for that individual attribute as compared to an established "regional reference" condition value (fish) or a "best metric value" (macroinvertebrates) based on IEPA's study and assessment of fish and macroinvertebrate communities in stream systems that are least disturbed by human impacts and similar in watershed/habitat characteristics to the LVR (IEPA, 2005 and IEPA, 2008b). The total fish community index (fIBI) or macroinvertebrate community index (mIBI) score is then calculated from the individual metric values and ranked into categories of "Integrity Class". The LVR watershed lies in the Bloomington Ridged Plain physiographic division, and is found within the IEPA-determined IBI Region 6. Thus, sample data were compared to reference streams (as established by IDNR and IEPA) found within the same region of the state. IEPA's macroinvertebrate bioassessment procedure (Tetra Tech, 2004; IEPA, 2007) has been developed for and applied in wadeable and non-wadeable streams and rivers throughout Illinois; sample data obtained for macroinvertebrates are compared with "best metric values one would typically expect to encounter" (IEPA, 2008b). Uncertainties associated with the IBI methods utilized at the Site are discussed in interpretation of the community assessment results.

The sample reaches for the current study were compared not only to the Illinois reference stream IBI scores determined by IDNR and IEPA, but also to a reference reach that was established upstream in the LVR and beyond any influence of the Matthiessen and Hegeler Zinc Company Site. This "same-stream" reference site was selected based on accessible upstream proximity to the Site and similarity in aquatic habitat as the subject/target sampling reaches adjacent to the Site. Establishing a same-stream reference reach of similar aquatic habitat allowed for comparisons between the subject/target reaches adjacent to the historical Matthiessen and Hegeler Zinc Company Site and a reach of the LVR that is upstream and unaffected by the Site.

2.1 Sampling Stations

Aquatic community surveys of the LVR were conducted within a minimum 330-foot (ft)/100-meter (m) river reach at four locations (Figure 2-1). These sample reaches were identified in the FSP (Appendix A) and include three target reaches (immediately adjacent to the Matthiessen and Hegeler Zinc Company Site) and one same-stream reference reach. The four selected sampling stations are:

- *Station CAR001* – this sample reach is the southernmost (and furthest downstream) reach and is located approximately 0.10 river mile upstream of the 5th Street (State Route 6) Bridge and immediately adjacent to the southern extent of the OU1 slag pile;

- *Station CAR002* – located approximately 0.21 river mile upstream of the 5th Street Bridge and immediately adjacent to the OU1 slag pile;

- *Station CAR003* - located 0.44 river mile upstream of the 5th Street Bridge at the northern end of the OU1 slag pile. Though adjacent to the slag pile, CAR003 was established just downstream of the City of LaSalle combined sewer outfall (CSO) and the abandoned sewer outfall (ASO) discharges associated with Operable Unit 2 (OU2); and,

- *Station CAR004 (Reference Reach)* – located approximately 2.32 river miles upstream of the 5th Street Bridge and upstream of the Matthiessen and Hegeler Zinc Company Site.

The table below provides additional information on the sample reach locations and reach dimensions.

Biological Assessment Sampling Reaches in the Little Vermilion River

Sampling Station	Latitude	Longitude	Sample Reach Length (Feet)	Mean Stream Width (Feet)
CAR001	41°20’04.33”N	89°04’56.45”W	405	45
CAR002	41°20’10.17”N	89°04’57.42”W	445	45
CAR003	41°20’20.71”N	89°04’49.55”W	443	40
CAR004 (Reference)	41°21’18.73”N	89°04’42.84”W	336	46

At each sampling reach, experienced field biologists (with U.S. EPA oversight) evaluated aquatic habitats, conducted fish and benthic macroinvertebrate (including mussels) community surveys, and collected tissue from aquatic organisms for laboratory analysis of site-related constituents. The field collection and evaluation methods for each of these activities are detailed in the following sections.

2.2 Habitat Assessment

The precise location of each sample reach was determined in the field during 19-20 May 2009, based on an initial aquatic habitat assessment conducted by experienced biologists with oversight provided by U.S. EPA representatives. The objective of this habitat assessment was to select river reaches of roughly comparable habitat in order to limit sample bias, as habitat characteristics are major factors that control the structure of aquatic communities.

The habitat assessment was comprised of two components: 1) an assessment of each sample reach patterned after the Ohio Environmental Protection Agency's qualitative habitat evaluation index (QHEI) to support comparison of in-stream habitats for sample sites located along the Site to those of the upstream reference reach, and 2) assessment of sample reach aquatic habitats for the purpose of allocating macroinvertebrate community sampling efforts.

2.2.1 Application of the QHEI

For application of the QHEI, field biologists visually surveyed each full sample reach, identified micro-habitat types, and scored the habitat for each full sample reach using the appropriate QHEI habitat metric such as: stream width, substrate type(s), channel morphology, riparian habitat, and riffle/pool complex. Although the majority of this assessment was qualitative, stream widths, slope, and stream depths (at riffles and runs) provide some quantitative measures. In lieu of stream drawings suggested on the QHEI form, photographs were taken of each stream reach surveyed to document general stream characteristics. The objective for the QHEI was to evaluate the sample reaches based on the six core QHEI metrics and to identify four sample reaches with habitat characteristics as similar as possible in order to provide the most representative comparison of the aquatic community between sampling locations. While slight variations in habitat features exist among the full sample reaches, primary characteristics were generally consistent throughout the four reaches.

2.2.2 Habitat Assessment for Macroinvertebrate Sampling

For the macroinvertebrate sampling-associated habitat assessment, each full sample reach was longitudinally divided into east and west halves, generally delineated by the stream thalweg. This approach ("split-river" design), which is a modification to the typical IEPA mIBI protocol, was adopted to satisfy the request of SulTRAC (U.S. EPA's oversight contractor) that the bioassessment study design for macroinvertebrate sampling maximize the ability to measure potential community impacts at the boundary between Site features and surface water. There was concern that Site-related impacts might not be measureable if traditional sampling methodologies inclusive of full river width were followed.

Within each half of the reach, experienced field biologists using best professional judgment identified the types and proportions of habitats present via visual and tactile clues (visual estimation approach). Resulting information was recorded in the field log book and subsequently used to representatively allocate macroinvertebrate sampling effort within each of the east and west halves of the LVR reaches sampled. Habitat types were identified as one of the seven habitats recognized by IEPA:

Bank-Zone Habitats	**Bottom-Zone Habitats**
1. submerged terrestrial vegetation	4. fine substrate
2. submerged tree roots	5. coarse substrate
3. brush-debris jams	6. plant detritus
	7. vegetation

As further described in Sections 2.4 and 3.1.2, the actual sampling of macroinvertebrate habitats was not conducted in strict accordance with the IEPA (2007) protocol, in part because the protocol was not designed to be applied in a split-river design. The impact of those deviations on interpreting the results of the macroinvertebrate sampling is also discussed herein.

Results of the QHEI- and macroinvertebrate sampling-associated habitat assessments are presented in Section 3.

2.2.3 Water Quality Measurements

As part of the habitat and biological community assessments, *in-situ* water quality parameters were measured and recorded at each station using an electronic water quality analyzer. Recorded parameters included dissolved oxygen concentration (mg/L), temperature (°C), pH, turbidity (NTU), and conductivity (µS/cm). Water depth was recorded with the aid of an eight-foot long metal wading rod marked in increments of tenths of feet. Standard units were converted to metric units for reporting (except in cases where fish metrics required wetted stream width to be evaluated under standard units). Sample reach lengths and channel widths were measured using a hip-chain distance measurer and/or measurement tapes. All data were recorded in the field log book, and later summarized into electronic format. Both habitat and water quality data were collected concurrent with each biological survey. Digital photographs were also taken of each reach during both the field reconnaissance and biological assessment (Figures 2-2 through 2-7).

Additionally, water velocity was measured at each sample reach using a Swoffer 3000 Flowmeter (velocity meter) following U.S. EPA/U.S. Geological Survey (USGS) methods

(Rantz, 1983). This approach allowed calculation of stream discharge as well (i.e., cubic feet per second [ft^3/s]).

2.3 Fish Community Sampling

Fish collection activities were conducted under authority of a scientific collection permit issued by the IDNR (Appendix C). Fish sampling was conducted during 11-13 August 2009 and included the full length and width of each sample reach (i.e., split-river design was applicable only to the macroinvertebrate sampling). Sample reaches varied in size (to account for slight changes in aquatic habitat, wadeable access, and block net placement), and were a minimum of 102 meters (336 feet) in length in order to adequately encompass the range of habitat conditions present in each sample area. Sample reaches varied in length from 102 meters (CAR004) to 136 meters (CAR002). Based on a review of historical IDNR fish sampling data, fish collection activities were targeted for about 30 minutes. A thorough sampling of CAR004, which was sampled first, took 36 minutes. Thereafter, all sample reaches were sampled for 36 minutes to maintain a consistent sample collection effort within each reach.

The fisheries survey was conducted within wadeable habitats of each reach using a non-electrified seine and a backpack electrofishing unit system, consisting of a battery-operated ABP-3 from Wisconsin Engineering Technical Services. Backpack electrofishing is generally consistent with IDNR stream sampling guidelines (IDNR, 2001); and, along with minnow seine, electric seine, boat electrofishing, rotenone or combinations thereof, was one of the methods used for the collection of fish samples supporting the development of the fIBI guidance for Illinois streams (IEPA, 2000). Use of backpack electrofishing is allowed when conditions do not permit the use of boat electrofishing or electric seine (IDNR, 2001), and the need to use backpack electrofishing in some portions of the LVR due to stream conditions was set forth in the FSP and approved (see Appendix A, Section 2.5.1.2). This was the case for the LVR reaches surveyed (particularly along the slag pile) as water depth was either too shallow for a boat or otherwise did not support safe access for boat electrofishing. Also, effective use of a seine was precluded by substrate roughness and shoreline features (this proved true for the non-electrified seine as well). The potential effect of using this sampling method is discussed further in interpretation of the fish community study results.

While electrofishing, one biologist operated the backpack unit while two additional biologists netted stunned fish with 1/8-inch mesh dip nets. Block nets were established at upstream and downstream reach termini to restrict fish passage and allow for more accurate sampling of fish communities within the reaches.

Electrofishing was conducted in a standardized fashion in a downstream to upstream direction and included all accessible riffle, run, and pool habitats present. Stunned fish were captured and temporarily held in 3-gallon buckets (equipped with battery-operated aerators) prior to handling and data collection. All fish were identified, enumerated, and examined for physical anomalies.

Except for a few voucher specimens that could not be identified in the field, all fish were returned to the stream. Data were recorded in the field log book. Upon return to the office, field data were checked for completeness and converted to electronic media.

Although not required as part of the metric scoring, any observations of deformities, eroded fins, lesions, or tumors (DELT) were reported during the fish identification and processing, and are included in the results section below.

2.3.1 Fisheries Data Management and Analysis

Raw fisheries data recorded in the log book were entered into electronic media and summarized in tabular format (Refer to Section 3.2). Fish metrics (measurements) were calculated and scored in the framework of IDNR's fIBI. The fIBI scores for the LVR sample reaches were then compared to reference or benchmark reaches identified in the same region of the state by IEPA as having "high biological integrity" (IEPA, 2000). The fIBI scores for LVR reaches adjacent to the Site (CAR001, CAR002, CAR003) were also compared directly to the LVR reference reach (CAR004). The 10 fish community metrics comprising the fIBI are:

1. *Total Number of Native Fish Species* – this metric is considered to be one of the most powerful metrics in determining stream condition because of the direct correlation between environmental conditions and the number of fish present in warmwater assemblages.

2. *Total Number of Native Sucker Species* – most suckers (Catostomidae) are sensitive to physical and chemical habitat degradation.

3. *Total Number of Native Sunfish Species* – this metric is a measure of the proportion of Centrarchidae taxa in a sample. Sunfish species can dominate stream sites undergoing environmental perturbations, especially the effects of nutrient enrichment. This metric may be less sensitive in rivers than in small wadeable streams where quality pool habitats are very important to sunfish presence.

4. *Total Number of Intolerant Species* – this metric distinguishes between sites of good and exceptional biotic integrity since species designated as environmentally intolerant would not be expected to be well-represented under degraded conditions

5. *Total Number of Native Minnow Species* – this metric is a measure of environmental quality because the number of native cyprinids (minnow species) present has been positively correlated with healthy streams.

6. *Total Number of Benthic Invertivore Species* – due to their specificity for feeding and breeding in benthic habitats, benthic invertivores tend to be highly sensitive to environmental degradation.

7. *Proportion of Specialist Benthic Invertivores* – specialist benthic invertivores are limited in their feeding for prey species and typically have unique morphology suited to their feeding preference. Because specialist benthic invertivores are less generalized in their prey selection, an increase in disturbance to a stream system generally causes a decrease in the proportion of specialist benthic invertivores in the aquatic community.

8. *Proportion of Generalist Feeders* – Because these species can forage on a variety of prey/food items, the proportion of generalist species is expected to increase in more disturbed streams.

9. *Proportion of Individuals as Mineral Substrate Spawners* – simple lithophils are fish that broadcast their eggs over the stream bottom where they can develop in the interstices of gravel, sand, and cobble and allow them to develop without parental care. Simple lithophils generally decline in number as habitat and water quality degrades, especially related to effects of sedimentation/siltation.

10. *Proportion of Tolerant Species* – Streams that are degraded, due to water quality, excess sedimentation, or other perturbations generally have a higher percentage of tolerant species within the aquatic community.

Individual metric scoring was performed based on metric scoring tables for fIBI Region 6, as provided by the IDNR. Eight of the ten metrics are scored (i.e., metric values assigned) based on the wetted stream width, which is determined by measuring the stream width to the boundaries of the water line (perpendicular to stream flow) at three locations within the reach and then calculating the mean width. The remaining two metrics (Proportion of Specialist Benthic Invertivores and Proportion of Generalist Feeders) do not take into account the wetted stream width.

Individual metrics (Metrics 1 through 10) are assigned a value of 0 to 6, depending on how the field measured parameter ranked according to IDNR's criteria. The final fIBI score for each station is calculated by summing individual metric values for each sampling station. This approach yields a maximum attainable fIBI score of 60 points. Resultant fIBI scores are then ranked into one of five "Integrity Classification" rankings (IEPA, 2005):

- Class 1 (fIBI score range of 56-60) - Biotic integrity is higher than that expected in Illinois streams that reflect the typical reference (i.e., least-disturbed) conditions, as currently defined. The number of native fish species is greater than that in streams reflecting the current, typical reference conditions primarily due to presence of intolerant species. Reproductive and trophic functional structure appear balanced;

- Class 2 (fIBI score range of 46-55) - Biotic integrity is similar to that expected in Illinois streams that reflect the typical reference conditions, as currently defined. Relative to conditions in Integrity Class 1, the number of native fish species is reduced primarily due to loss of some intolerant species. Reduced abundances of mineral-substrate spawners indicate slight imbalance in reproductive functional structure;

- Class 3 (fIBI score range of 31-45) - Biotic integrity is lower than that expected in Illinois streams that reflect the typical reference conditions, as currently defined. Number of native fish species is reduced from reference conditions primarily due to further loss of intolerant species, but also due to loss of sucker species and benthic-invertivore species. Reduced abundances of specialist benthic invertivores and increased abundances of generalist feeders indicate slight to moderate imbalance in trophic functional structure. Further reduction in abundances of mineral-substrate spawners indicates moderate imbalance in reproductive functional structure;

- Class 4 (fIBI score range of 16-30) - Biotic integrity is much lower than that expected in Illinois streams that reflect the typical reference conditions, as currently defined. Number of native species is reduced further from reference conditions due to near-complete loss of intolerant species and further pronounced loss of sucker species and benthic-invertivore species. Imbalance of fish-community structure is evidenced as indiscriminate loss of species across major families (minnows, suckers, sunfish). Further reductions in abundances of specialist benthic invertivores and mineral-substrate spawners indicate moderate to extreme imbalance in trophic and reproductive functional structure; and,

- Class 5 (fIBI score range of 0-15) - Biotic integrity is much lower than that expected in Illinois streams that reflect the typical reference conditions, as currently defined. Number of native species is reduced further due to pronounced, indiscriminate loss of species across major families (minnows, suckers, sunfish) with a concurrent increase in the proportion of tolerant species. Intolerant species are absent; benthic-invertivore species are nearly absent. Pronounced reductions in abundances of specialist benthic invertivores and mineral-substrate spawners indicate extreme imbalance in trophic and reproductive functional structure.

The multi-metric based protocol provides a sound, ecologically-based framework and proven tool for comparing the biological integrity of fish communities from like habitats in the study area. Total fIBI scores for the sampled reaches of the LVR were developed based on comparison of individual community attributes (i.e., metrics) that were compared to the IEPA-established regional reference data for the applicable fIBI region (IEPA, 2000).

Further, the fIBI scores and other aquatic community measures (i.e., diversity indices) of the sampling reaches adjacent to the Matthiessen and Hegeler Zinc Company Site (CAR001, CAR002, and CAR003) were compared to the upstream reference reach (CAR004) fIBI score. Per the IEPA guidance: "any Illinois [fish]IBI-score difference of ten or less should not be interpreted as a meaningful difference in biotic integrity" (IEPA, 2005). Based on review of this guidance and statistical context of the statement, it is interpreted that an fIBI score within plus or minus 5 of another fIBI score indicates no meaningful difference in biotic integrity.

2.4 Benthic Macroinvertebrate Community Sampling

As indicated previously, each sample reach was longitudinally divided into east and west halves, generally delineated by the stream thalweg. Aquatic (benthic) macroinvertebrate community sampling was conducted in each half of the four selected sample reaches. In accordance with the IEPA (2007) draft field collection protocol, macroinvertebrate community sampling was conducted using a 20-jab multi-habitat collection method combined with a 300-organism laboratory subsample (IEPA, 2001).

According to IEPA (2007) protocol, the 20-jabs should first be distributed between bank-zone and bottom-zone habitats based on the ratio specified in the protocol for the wetted stream width. For example, if a full wetted width of the stream falls in the range of 10-29 feet, then the protocol specifies that 40 percent of the jab samples are to be allocated to bank-zone habitats and 60 percent to bottom-zone habitats. Then, within each of the bank-zone and bottom-zone habitat categories, the jabs are proportionally distributed to the habitats identified by the visual estimation approach (IEPA, 2007). For the current study, however, the 20-jabs were distributed using the habitat visual estimation approach to the entire half reach without using the bank-zone and bottom-zone sample ratios specified by the IEPA (2007) protocol. The potential effect of modifying the IEPA macroinvertebrate sampling protocol is discussed further in interpretation of the macroinvertebrate community assessment results.

Once the proportional number and location of macroinvertebrate sampling points were determined based on habitat proportions for each half reach (east and west halves), sampling (individual jabs/dips) was conducted using a standard long-handled D-frame dipnet (approximately 1-foot frame width) with 500 micron mesh netting.

Samples were processed in accordance with the FSP (Appendix A) and shipped to the laboratory (Pennington & Associates, Inc., Cookeville, Tennessee) for processing. All samples were submitted under chain-of-custody and were received in good condition prior to processing for enumeration and taxonomic identification.

The resultant macroinvertebrate community data were comparatively evaluated within and among each sample reach (see Section 3.3).

2.4.1 Freshwater Mussels

As part of the macroinvertebrate community survey, additional effort was targeted towards determining the status of freshwater mussel populations in each sample reach. The freshwater mussel community was surveyed for the presence/absence of mussels at each sample reach via timed searches of one hour conducted by three personnel (total of 3 man-hour surveys). Search techniques included hand-picking of mussels using viewing buckets (in shallow areas and along stream banks) and snorkeling (in deeper areas of each reach).

Mussel specimens were identified in the field and a limited number of common species were collected and processed as part of the biotic tissue analysis (see Section 2.5).

2.4.2 Macroinvertebrate Data Management and Analysis

The raw macroinvertebrate data obtained from the laboratory and reflecting all specimens collected in the field were entered into electronic format tabular summaries and are provided in Appendix D. These data were then subjected to IEPA's standardization procedures (IEPA, 2008b) whereby data reduction procedures are applied where necessary to achieve the preferred sample size of 300 organisms (+/- 20 percent); certain taxonomic levels are grouped, unqualified taxa (e.g., those not considered fully aquatic) omitted, and taxa-specific pollution tolerance values and functional feeding group classifications assigned, prior to determination of individual mIBI metric values and calculation of mIBI scores.

The seven IEPA macroinvertebrate community metrics comprising the mIBI are:

1. *Number of Coleoptera Taxa* – this metric is a measure of the number of Coleoptera genera identified in the sample. This number generally decreases in response to perturbations (sometimes called stressors) to the stream reach.

2. *Number of Ephemeroptera Taxa* – this richness metric measures the number of Ephemeroptera genera (mayflies) identified in the sample. This number generally decreases in response to perturbations to the stream reach.

3. *Total Taxa* – this metric provides a measurement of the overall diversity/richness of the sample reach. A greater assigned value for this metric indicates overall stream health, and can be affected by the diversity of habitats and/or water quality.

4. *Intolerant Taxa* – this metric of sensitive species utilizes tolerance values provided by IEPA; intolerant taxa are those genera with a tolerance value equal to or less than 3.0. The number of intolerant taxa decreases in response to poor water quality, siltation, or other stream perturbations.

5. *Macroinvertebrate Biotic Index (MBI)* – this tolerance metric is a component of the overall mIBI and provides insight into community structure and indicates the average pollution tolerance (weighted by the number of individuals in the standardized dataset) for the benthic macroinvertebrate community as a whole. The higher the MBI metric value, the more degraded the stream system.

6. *Percent Individuals as Scrapers* – this trophic metric measures the proportion of individual species in the sample that forage by scraping periphyton from stream substrates. In general, scraper taxa require silt-/sediment-free habitat to forage. Therefore, the proportion of scrapers will decrease in response to degraded stream systems.

7. *Percent EPT (Ephemeroptera, Plecoptera, and Trichoptera)* – this metric is a measure of the proportion of individual species in a sample represented by the EPT taxonomic Orders. Higher percentage of organisms in these groups is generally associated with improved water quality.

IEPA has established a best metric value (IEPA, 2008b) for each of the individual mIBI metrics listed above. The IEPA best metric values are those that would typically be expected to occur in an undisturbed/least disturbed stream and are provided in the table below.

IEPA's Best Metric Values

Metric	Response to Stressors	Best Metric Value
Coleoptera Taxa	Decrease	5.0
Ephemeroptera Taxa	Decrease	10.2
Total Taxa	Decrease	46
Intolerant Taxa	Decrease	9.0
Macroinvertebrate Biotic Index	Increase	4.9
Percent Scraper	Decrease	29.6
Percent EPT	Decrease	74.0

After determining the metric values for each half-reach, each was assigned a standardized metric score based on the percentage of the IEPA best metric value (IEPA, 2008b). For the six metrics where a decrease in value occurs as a response to perturbation, any half-reach metric value that is equal to or greater than the best metric value is given a score of 100. For the MBI metric (where there is a numerical increase in response to perturbation), a score of 100 is given where the half-reach metric value is less than or equal to the best metric value. Because sample metrics that are better than IEPA's best metric value only receive a score of 100, this process has some conservative bias.

The standardized half-reach metric values were averaged to produce the overall mIBI score, which was then ranked among four "Macroinvertebrate IBI Quality Categories" based on lower and upper boundary score ranges developed by IEPA (IEPA, 2008b). For the purposes of this study, narrative descriptions for mIBI "Quality Categories" provided by IEPA (2008b) are considered generally analogous to those previously presented for the fIBI Integrity Classifications. Specific to the mIBI, Integrity Classification descriptions are:

- Class 1 (mIBI score range of 73.0-100) - Biotic integrity is higher than that expected in Illinois streams that reflect the typical reference (i.e., least-disturbed) conditions, as currently defined;

- Class 2 (mIBI score range of 41.8-72.9) - Biotic integrity is similar to that expected in Illinois streams that reflect the typical reference conditions, as currently defined;

- Class 3 (mIBI score range of 20.9-41.7) - Biotic integrity is lower than that expected in Illinois streams that reflect the typical reference conditions, as currently defined; and,

- Class 4 (mIBI score range of 0.0-20.8) - Biotic integrity is much lower than that expected in Illinois streams that reflect the typical reference conditions, as currently defined.

Uncertainties associated with best metric value comparisons are discussed further in interpretation of the macroinvertebrate community assessment results.

2.5 Fish and Mussel Tissue Collection

In the conduct of fish community sampling, selected fish and mussel species were retained for biotic tissue analysis to support additional evaluations and lines of evidence to be considered under the weight-of-evidence approach to the CERCLA-driven BERA and the human health risk assessment (HHRA) being conducted for OU1. For the BERA, samples of forage/prey fish and freshwater mussels were collected for total body burden analysis. For the HHRA, a sportfish (potential food-fish species) was selected. Initially, biotic tissue sample collections were proposed from three community reaches (CAR001, CAR003, and CAR004) to evaluate body burden. However, due to the scarcity of target-sized individuals, and in order to ensure an adequate sample size for accurate analysis, samples were also collected at CAR002.

As a result, target species and number of samples (in particular, mussels) at each reach were modified in the field, based on availability/abundance, and are listed below.

- <u>Forage/Preyfish Species</u>
    - Northern hogsucker, *Hypentelium nigricans*
- <u>Sportfish/Predator Species</u>

    - Smallmouth bass, *Micropterus dolomieu*
    - Sauger, *Sander canadensis*

- Freshwater Mussel Species

    - Plain pocketbook, *Lampsilis cardium*

One prey fish species, one freshwater mussel species (where available), and one sportfish species were collected for biotic tissue analysis from the four established sample reaches. Although every effort was made to retain the same species across sample reaches, the sportfish species for CAR002 was limited to a whole body analysis of smallmouth bass.

Live mussel specimens were rare for all sample reaches; only one plain pocketbook each was collected at CAR001, CAR002, and CAR003. Plain pocketbook was not present at the reference reach (CAR004); only one specimen of ellipse (*Venustaconcha ellilpsiformis*) was observed at this location. Because this species is listed as a species of special concern in Illinois, it was immediately released. Although only one plain pocketbook was collected (each) at CAR001, CAR002, and CAR003, these specimens were retained and processed for tissue analysis. The table below presents the target species obtained and their trophic level, sample reach location, and process method (whole body or filet). In some instances, a single individual yielded both filet and whole body samples.

Fish and Mussel Tissue Collection Parameters

Sample Reach	Target Species	Trophic Level	Process Method
CAR001			
	Northern hogsucker	Forage/Prey	Whole Body
	Smallmouth bass	Predator/Sportfish	Whole Body
	Smallmouth bass	Predator/Sportfish	Filet
	Plain pocketbook	Mussel/Filterer	Whole Body
CAR002			
	Northern hogsucker	Forage/Prey	Whole Body
	Smallmouth bass	Predator/Sportfish	Whole Body
	Plain pocketbook	Mussel/Filterer	Whole Body
CAR003			
	Northern hogsucker	Forage/Prey	Whole Body
	Smallmouth bass	Predator/Sportfish	Whole Body
	Sauger	Predator/Sportfish	Whole Body
	Sauger	Predator/Sportfish	Filet
	Plain pocketbook	Mussel/Filterer	Whole Body
CAR004			
	Northern hogsucker	Forage/Prey	Whole Body
	Smallmouth bass	Predator/Sportfish	Whole Body

Other than changes to the tissue collection protocol mentioned above, the remaining standard operating procedures for sample processing were followed in accordance with the FSP (Appendix A).

Data collected during tissue collection were recorded in the log book including: date, time and location of sampling; investigators performing sampling; type of gear used to complete the task when applicable; weather conditions during sampling; sample processing and preservation when applicable; common name, length and weight of species sampled; and any physical anomalies observed in sample specimens.

Composited biotic tissue samples were analyzed (using U.S. EPA Methods 6010B/6020A/7471A) for the following metals: arsenic, cadmium copper, lead, mercury, silver, and zinc. These metals were selected primarily based on the results of surface water and sediment analyses for samples collected from the LVR during the CERCLA Phase 1 investigation. Notably, these metals (except mercury) were measured at levels above U.S. EPA Region 5 Ecological Screening Levels[1] at one or more sediment or surface water locations. Mercury was added to the list at U.S. EPA's request due to its detection in other Site media and its bioaccumulative properties. Analysis of lipids was also performed as referenced in the Quality Assurance Project Plan (QAPP) Addendum No. 1 (Geosyntec, 2007). Analyte concentrations in biotic tissue are reported based on dry-weight of the sample.

Reporting of the results of the laboratory analyses of these tissue samples and evaluation of those results in the context of the HHRA and the BERA weight-of-evidence are included in Sections 2 and 4, respectively, of the Risk Assessment (Appendix RA of the RI Report).

[1] Source: http://www.epa.gov/reg5rcra/ca/ESL.pdf

3.0 RESULTS

This section presents the results of the biological assessment of the aquatic communities in the LVR in proximity to the Matthiessen and Hegeler Zinc Company Site. The biological assessment was conducted within four river reaches (three along the Site and one reference reach) and consisted of four major tasks: 1) habitat assessment; 2) fish community assessment; 3) aquatic macroinvertebrate community assessment (including mussels); and 4) fish and mussel tissue analysis. Uncertainties associated with the biological assessment components are discussed in the following sections in interpretation of the results.

3.1 Habitat Assessment

The selected LVR sample reaches were chosen based on similar physical habitat characteristics, evaluated across the full LVR width, and their spatial relationship with the Matthiessen and Hegeler Zinc Company Site. Final sampling reach lengths ranged from 336 feet (102 meters) to 445 feet (136 meters), and were determined by the following criteria:

- A 330-feet/100-meter minimum length;
- A reach length suitable to capture appropriate habitat types (riffle, pool, glide, etc.); and
- Reach termini established based on the ability to deploy block nets at narrow points during fish sampling efforts.

Upon establishing the final sample reach lengths, field biologists completed the QHEI forms to qualitatively evaluate consistency in stream habitats between sample reaches.

3.1.1 Physical Stream Habitat Conditions

<u>CAR001</u>

Sample reach CAR001 is the southernmost reach and is located east and adjacent to the Carus Plant holding pond, and a riparian forest, cemetery, agricultural fields, and former rock quarry property (to the east). The holding pond discharges to this reach of the LVR via a NPDES-permitted outfall. Sample reach CAR001 averaged 45 feet wide and had an average flow discharge of 50.27 ft^3/s. The channel slope along this 405-foot reach is 0.72 percent. This reach contains four or more substrate types, with moderate amounts of in-stream cover. This location has low sinuosity with good development, and may be recovering from previous channelization. The adjacent eastern riparian zone for reach CAR001 is relatively wide with forest, cemetery, agricultural fields, and former quarry lands (designated for future use as a park). Very little bank erosion was observed. This reach scored well for the presence of riffle/pool complex habitat due to deep riffle depths and wide pool measurements (wider than riffles). Stream flow velocity at this reach was determined to be fast and the riffle/run substrate appeared stable. Overall, CAR001 scored (QHEI) 74 out of 100 during the stream habitat evaluation.

CAR002

Sample reach CAR002 is located upstream (north) of CAR001 and immediately adjacent of the large slag pile/slope that forms the stream bank to the west. This sample reach averaged 45 feet wide and had an average flow discharge of 44.28 ft^3/s. The slope along this 445-foot reach is 2.87 percent, exhibiting the highest gradient among all sampling reaches surveyed. CAR002 also contains four or more substrate types, and is dominated by boulders and gravel. A “normal” amount of silt is present in this reach. In-stream habitat includes pools, boulders, woody debris, shallows, and emergent and overhanging vegetation. Channel morphology exhibits moderate sinuosity with good development. This reach was determined to be near full recovery of past channel modifications and considered stable; meaning the reach has recovered most of its natural channel characteristics, but still exhibits some areas of poor channel features not as supportive of healthy aquatic communities. Riparian habitat was determined to be good, with wide forested slope habitats along the eastern stream boundary and more moderate riparian habitat on the western side, due to the presence of the slag pile. Similar to CAR001, this sample reach contains deep riffles, and pool widths that are wider than the riffles. This reach contains both fast and slow areas of stream flow. Riffle substrate was considered stable. CAR002 scored (QHEI) a 79 out of a possible 100 during the stream habitat evaluation.

CAR003

CAR003 is located upstream of CAR002 and immediately adjacent to the northern extent of the slag pile/fill slope. A City of LaSalle CSO and an ASO draining portions of OU2 are located just upstream of this reach. Sample reach CAR003 averaged 40 feet wide and had an average flow discharge of 49.22 ft^3/s. The slope along this 443-foot reach is 0.35 percent. Four or more substrate types were observed in this sample reach and in-stream cover was moderate, containing a variety of overhanging vegetation, root mats, shallows, pools, root wads, boulders, and woody debris. The channel morphology within CAR003 was determined to contain moderate sinuosity with good development. This stream segment appears to be at full recovery from past channel modifications and the stream appears stable; however, poor channel features remain in some areas of the reach. Riparian habitat is narrow along the western edge, due to the encroaching fill slope of the slag pile. The eastern edge remains wide with forested slopes. Little to no erosion was observed at the bank edge. This segment of stream scored high for its diverse riffle/pool complexes. Stream flow velocities were rated high in riffle reaches and slow to moderate in the pool/glide habitats. CAR003 scored (QHEI) an 83 out of a possible 100 during the stream habitat evaluation.

CAR004-Reference Reach

CAR004 is located approximately 1.9 river miles upstream (north) of CAR003, within an area largely undisturbed from human impact (other than from past agricultural operations and some residential development). A comparison of stream sediment samples collected adjacent to the Site to samples collected upstream of the Site indicate that the reference reach sediments have not been impacted by airborne deposition of contaminants from historic Site activities (Attachment E). In addition, the sample results of the residential soils north of the Site (in the direction of the reference reach) generally show a lack of impacted soils between the Site and the reference reach (see Figures 4.2.2-14 through 4.2.2-18 of the RI Report).

Sample reach CAR004 averaged 46 feet wide and had an average flow discharge of 56.35 ft^3/s. The slope along this 333-foot reach is 0.18 percent, representing the lowest gradient of all four sampling reaches. Similar to the other sample reaches, CAR004 contains four or more substrate types with “normal” silt loads. In-stream cover includes overhanging vegetation, shallows, root mats, pools, rootwads, emergent vegetation, and woody debris. Channel morphology displayed moderate sinuosity with good development. No channel modifications/channelization was observed and the reach showed moderate stability. One side of the stream shows evidence of bank shaping, but riparian habitat is wide on both sides of the river. However, much of the area outside of the immediate riparian zone is occupied in shrub/oldfield habitat. This reach contained deep riffles, and the riffle widths were equal to that of the pool widths. The riffle/run substrate appears stable, with low embeddedness. Stream flow velocities were rated moderate in riffle reaches and slow to moderate in the pool/glide habitats. CAR004 scored (QHEI) an 84 out of a possible 100 during the stream habitat evaluation.

Overall, the type and quality of aquatic habitats observed at CAR001, CAR002, and CAR003 were similar and comparable to aquatic habitat within CAR004. Having comparable stream habitat provides for a more unbiased interpretation of aquatic biota data across sampling sites. Sample reaches scored within 10 points (~8 percent) of each other, and the average score of the slag pile reaches combined was within 5.5 points of the reference reach score. The study reaches (CAR001, CAR002, and CAR003) averaged 78.6 (out of 100), while the reference reach was given a score of 84.0. All reaches contained four or more substrates (dominated by coarse substrates) with similar in-stream cover. Channel morphology and riffle/pool characteristics were generally similar throughout. Two of the largest differences in stream reaches, which led to slight variations in scoring, are related to riparian widths and stream bank modifications (not unexpected). Notable variation in percent slope was also observed among sample reaches. Copies of the QHEI score sheets are provided in Appendix B.

3.1.2 Habitat Assessment for Macroinvertebrate Sampling

Based on the macroinvertebrate-sampling associated habitat assessment, the average wetted stream width ranged from 40 to 46 feet for the sampled reaches. Bottom-zone habitats were dominated by coarse substrates at all river reaches. Submerged terrestrial vegetation, tree roots and brush/debris jams habitat types were, in general, evenly represented in the bank-zone of each river reach.

Macroinvertebrate sampling was conducted proportionally to the habitats identified within a given reach half based on the visual estimation approach. For example; if by visual estimation ¾ of the habitat in a particular reach half was composed of coarse substrates, then ¾ of the macroinvertebrate samples for that reach half were collected from coarse substrates, and so on. The following table summarizes the number of jabs/dips for the various habitat types present at the LVR reaches sampled and indicates whether those jabs/dips are recognized by IEPA as bank-zone or bottom-zone habitats.

Macroinvertebrate Community Sampling Effort by Habitat Type

Sample Reach	Bank-Zone Habitats				Bottom-Zone Habitats*			Total Jabs
	Submerged Terrestrial Vegetation	Submerged Tree Roots	Brush-Debris Jams	No. Jabs/Dips	Coarse Substrate	Stream Bottom Vegetation	No. Jabs/Dips	
CAR001 East	2	1	1	**4**	15	1	**16**	**20**
CAR001 West	2	2	3	**7**	12	1	**13**	**20**
CAR002 East	2	2	2	**6**	14	0	**14**	**20**
CAR002 West	2	2	2	**6**	14	0	**14**	**20**
CAR003 East	2	5	5	**12**	8	0	**8**	**20**
CAR003 West	2	4	2	**8**	12	0	**12**	**20**
CAR004 East	6	3	2	**11**	9	0	**9**	**20**
CAR004 West	4	4	2	**10**	10	0	**10**	**20**

*As indicated previously, IEPA recognizes four bottom-zone habitats. The habitat assessment associated with the macroinvertebrate sampling for this project only identified the two bottom-zone habitats included in the table and did not identify fine substrate or plant detritus habitats.

As reflected in the table, the number of jabs/dips in different habitat types and in the bank-zone and bottom-zone categories varied between the LVR macroinvertebrate sampling locations. This was a result of the difference in available habitats at the various LVR reach halves. As stated previously, the Site jab/dip allocation method was not in strict accordance with the IEPA (2007) sampling protocol. According to IEPA (2007) sampling protocol, the number of bank-zone and bottom-zone samples should first be set based on the ratio specified by the protocol for the full mean wetted stream width and, then, the samples should be further distributed proportionally to the habitats observed in the field within each of the bank-zone and bottom-zone categories. The average wetted stream widths at the Site ranged from 40 to 46 ft, which are all with within the IEPA 30-59 ft range category. Based on this range category, the protocol specifies that 30 percent of the jabs/dips should be allocated to the bank-zone (n=6) and 70 percent (n=14) should be allocated to the bottom-zone (referenced hereafter as the '6/14 allocation').

Although not specified by the IEPA protocol, if it is assumed that the 6/14 allocation would also apply to a half-river segment, then, as indicated in the table, the macroinvertebrate sampling-associated habitat assessment at CAR002 resulted in jab/dip allocation consistent with the 6/14 allocation. However, relative to the 6/14 allocation, fewer bank-zone samples were collected at CAR001 East, and more bank-zone samples were collected at CAR001 West, CAR003 East and West, and CAR 004 (reference reach) East and West. Whether this difference in sample allocation between bank-zone and bottom-zone impacts the comparison of the mIBI values for the sampled reaches of the LVR to the IEPA best metric values is discussed in Section 3.3.6.2.

3.1.3 Water Quality Conditions

Stream water quality data suggest conditions of a warm-water, alkaline stream system. Temperatures varied from 21.95 °C at CAR003 to a slightly warmer 23.62 °C at CAR002. Conductivity remained relatively consistent and moderately high, averaging 809 µS/cm for all sample reaches. Dissolved oxygen concentrations were good throughout ranging from 8.03 mg/L (CAR001) to 8.98 mg/L (CAR002). Turbidity values were somewhat elevated, likely due to recent rainfall within the watershed, indicating turbid/stained water conditions during the sampling event. Of note, pH levels were relatively high throughout, which may be attributed to an alkaline substrate (such as limestone) in this watershed. The table below summarizes water quality findings along with QHEI scores for all four sampling reaches.

Summary of Water Quality Conditions and QHEI Scores for Little Vermilion River Sample Reaches, 11-13 August 2009.

Sampling Reach	**Average Stream Width** (ft)	**Stream Flow Discharge** (ft^3/s)	**Slope** (%)	**QHEI Score (out of 100)**	**Temp** (°C)	**Conduc-tivity** (µS/cm)	**Dissolved Oxygen** (mg/L)	**pH**	**Turbidity** (NTU)
CAR001	45	50.27	0.72	74	21.98	819	8.03	8.45	21.7
CAR002	45	44.28	2.87	79	23.62	819	8.98	8.50	20.7
CAR003	40	49.22	0.35	83	21.95	803	8.07	8.45	27.3
CAR004	46	56.35	0.18	84	22.33	796	8.71	8.06	17.7

3.2 Fish Community Assessment

Fish community sampling was conducted at Stations CAR001 through CAR004 during 11-13 August 2009. A checklist of fishes collected in the investigation area along with their taxonomic nomenclature is presented in Table 3-1. A summary of fish species collected at each station, their relative abundance, trophic classification, and other attributes used to assess biotic integrity is presented in Tables 3-2 through 3-5.

3.2.1 Sample Reach CAR001

A total of 107 fish representing 15 species were collected at CAR001 (Table 3-2). Dominant species were central stoneroller, *Campostoma anomalum*, (29.0 percent), northern hogsucker, *Hypentelium nigricans,* (27.1 percent), spotfin shiner, *Cyprinella spiloptera,* (9.3 percent), and logperch, *Percina caprodes*, (8.4 percent). The remaining 26.2 percent of the catch was dispersed among 11 other species.

Five fish families were represented in the catch at CAR001. Dominant families were Cyprinidae (44.9 percent) and Catostomidae (33.6 percent). Approximately 10 percent of the catch consisted of either Centrarchids or Percids. The Ictaluridae family was represented by one individual (< 1 percent).

Five trophic (feeding group) classes were represented at CAR001 including five benthic invertivores, two top carnivores, three generalists, three omnivores, and two herbivores.

Thirty-six minutes of electrofishing effort was expended at CAR001, yielding an electrofishing catch-per-unit-effort (CPUE) of approximately three fish per minute[2]. Only one observation of DELT was observed at CAR001; a parasite observed on the pectoral fin of a hornyhead chub, *Nocomis biguttatus*.

3.2.2 Sample Reach CAR002

A total of 53 fish representing 15 species were collected at CAR002 (Table 3-3). Dominant species were bluegill, *Lepomis macrochirus* (32.1 percent), logperch, (13.2 percent), green sunfish, *Lepomis cyanellus* (9.4 percent), northern hogsucker, (9.4 percent), shorthead redhorse, *Moxostoma macrolepidotum*, (7.5 percent), and banded darter, *Etheostoma zonale* (7.5 percent). The remaining nine species in the catch at CAR002 each averaged about 2.3 percent of the total catch.

[2] Electrofishing (backpack) was the predominant sample method. Non-electrified seine hauls conducted at each reach after electrofishing produced virtually no fish; thus, the one or two fish that were collected (most reaches produced no fish) were combined with the electrofishing sample. This had minimal effect on CPUE.

Four fish families were represented in the catch at CAR002. The dominant family was represented by Centrarchidae (47.2 percent). Catostomidae (20.8 percent), Percidae (20.8 percent), and Cyprinidae (11.2 percent) comprised the remaining catch.

Five trophic (feeding group) classes were represented at CAR002, including five insectivore species, one top carnivore, four generalists, four omnivores, and one herbivore (Table 3-3).

The 36 minutes of electrofishing effort expended at CAR002 yielded an electrofishing CPUE of 1.5 fish per minute. Only one instance of DELT was observed during the examination of fish collected at CAR002, which was associated with a parasite on the pectoral fin of a bluegill.

3.2.3 Sample Reach CAR003

A total of 61 fish representing 16 species were collected at CAR003 (Table 3-4). Dominant species included northern hogsucker (26.2 percent), bluegill (18.0 percent), black redhorse, *Moxostoma duquesnei* (11.5 percent), redfin shiner, *Lythrurus umbratilis* (9.8 percent), and logperch (8.2 percent). All other taxa were comprised of one to two individuals for each species.

Five fish families represented in the catch at CAR003 were dominated by Catostomidae (41.0 percent), Centrarchidae (27.9 percent), and Cyprinidae (19.7 percent). Percidae (9.8 percent) and Sciaenidae (1.6 percent) accounted for the remaining families.

The fish catch at CAR003 represented five trophic classes including five benthic invertivores, three top carnivores, one omnivore, one herbivore, and five generalists.

The 36 minutes of electrofishing effort expended at CAR003 yielded an electrofishing CPUE of 1.7 fish per minute. Of the 61 fish collected, only one instance of DELT was observed: a parasite on the pectoral fin of a bluegill.

3.2.4 Sample Reach CAR004 (Reference Reach)

A total of 172 fish representing 19 species were collected at CAR004 (Table 3-5). Dominant species included bluntnose minnow, *Pimephales notatus* (30.2 percent), northern hogsucker (25.0 percent), and Johnny darter, *Etheostoma nigrum* (10.5 percent). The remaining taxa were represented by nine or fewer individuals for each species.

Four fish families are represented in the catch at CAR004 and are dominated by Cyprinidae (44.0 percent) and Catostomidae (31.4 percent). Percidae (16.2 percent) and Centrarchidae (6.4 percent) accounted for the remaining families.

The fish catch at CAR004 represented five trophic classes including six benthic invertivores, two top carnivores, one omnivore, one herbivore, and nine generalists.

The 36 minutes of electrofishing effort expended at CAR004 yielded an electrofishing CPUE of 4.8 fish per minute. There were no instances of DELT on any of the fish observed within this sample reach.

3.2.5 Fish Community Index of Biotic Integrity (fIBI)

Examination of the individual metrics indicate that the fish communities of CAR001, -002, and -003 each reflect a fish community of moderate diversity and health. Compared to historical IDNR fish sample data for the LVR, all sites (including the reference reach) were somewhat lacking in species richness, yet they all scored well on trophic/reproductive-structure and pollution tolerance metrics. The range of trophic diversity observed at CAR001 through CAR003 is similar, containing a relatively even distribution of benthic invertivores, generalists/omnivores, and predatory species. One of the lower metric scores observed for all three reaches adjacent to the Site was the relatively few numbers of native minnows.

Overall, six fish families were represented in the fish community assessment. Cyprinidae, Catostomidae, Centrarchidae, and Percidae were observed in all four sampling reaches. The family Ictaluridae, represented by one specimen of channel catfish (*Ictalurus punctatus*), was only observed in CAR001. One freshwater drum (*Aplodinotus grunniens*), of the family Sciaenidae, was observed at CAR003. No State or Federal-listed fish species were observed at any of the sampling stations.

Under IEPA's protocol, the maximum fIBI score attainable is 60 points. Input parameters for the fIBI and metric scores are presented in Tables 3-6 through 3-9, with summary scores for all four sites presented in Table 3-10. Total fIBI scores for sample reaches CAR001, CAR002, CAR003, and CAR004 were 43, 43, 42, and 44, respectively. All of these scores are in fIBI Integrity Class 3, which is described as having lower biotic integrity than typically expected for Illinois reference streams. Because the scores for CAR001, CAR002, and CAR003 are within 1 to 2 points of the score for CAR004, the LVR reaches sampled in this study are ecologically similar in terms of fish biotic integrity. Thus, it is reasonable to conclude that the condition of the fish community in the LVR adjacent to the Site is not materially different from the "background" conditions as measured at the reference reach (CAR004).

3.2.6 Fish Community Survey Uncertainty

The number of fish collected at two of the LVR reaches (n=53 at CAR002 and n=61 at CAR003) was somewhat lower than the number collected at the other reaches (n=107 at CAR001 and n=172 at CAR004). No direct comparison to fish sample counts in prior sampling events at reaches adjacent to the Site is possible. Based on review of the available resources, IEPA/IDNR have not conducted fish surveys in the LVR downstream of their basin monitoring station DR-11 (the same as current study location CAR004). Two prior sampling events conducted by IDNR at DR-11/CAR004 have been reported: one in 1993 yielding 172 fish and another in 1999 when

661 fish were collected (IDNR, 2000). Normalized, based on CPUE, to the 36 minutes of sampling effort for the current study; theoretically, 103 fish and 643 fish would have been collected in 1993 and 1999, respectively. When these historical data for DR-11/CAR004 are compared to the collection in 2009, they seem to show some variability in simple fish counts, but do not suggest any "undersampling" based on the sample methods used in this study.

At the same time as the collection efforts for this study, IDNR/IEPA biologists collected 84 fish at LVR reach DR-03, which is at the Civic Road Bridge crossing located approximately 1 mile upstream of CAR004 (IDNR, 2010). Review of historical IDNR data for DR-03 indicates that 218 fish were collected in a 1993 survey and 96 fish were collected in 1989 (IDNR, 2000). This equates to 196 fish and 112 fish, respectively, when normalized to the current study effort based on CPUE; thus again demonstrating some variability in fish sample counts. The 2009 fish samples were collected by IDNR at DR-03 using collection methods (electrofishing and seining) generally comparable to those used in this assessment, but with somewhat less sampling effort (25 minutes at DR-03 vs. 36 minutes at CAR004). Based on DR-03 CPUE (3.36 fish per minute) normalized to 36 minutes, an estimated 121 fish would theoretically have been collected at DR-03 with an additional 11 minutes of electrofishing effort. This is similar to the fish sample count obtained by backpack electrofishing at CAR001 and quite a bit lower than the count obtained at CAR004. Based on these analyses, the lower sample counts are not attributed to any systematic "undersampling" due to the collection methods used in the current study.

The difference in fish counts among the sampled reaches could partly be due to conditions at the different reaches. Backpack electrofishing sampling efficiency was greater at CAR004 because the reach was generally more accessible/wadeable than the other reaches. In contrast, difficult physical conditions and fast river flow made backpack electrofishing and seining more difficult and likely less effective along reaches adjacent to the Site. Effective seining is difficult in coarse substrate environments (because gaps are difficult to avoid between the seine and the coarse substrate), and the areas along the Site had higher amounts of such substrate. This difficulty was anticipated in the FSP, and the use of backpack electrofishing was proposed and approved (see Appendix A, Section 2.5.1.2). As indicated previously, this is one of several sample methods used for the collection of fish samples supporting the development of the fIBI guidance for Illinois streams (IEPA, 2000); however, it was not used by IEPA in any of the 40-ft wide streams that make up the database for developing regional fIBI values. As such, a concern existed that the use of backpack electrofishing may have resulted in relatively less efficient sampling that could reduce the reliability of the proportional metrics that contribute to the final fIBI. Additional effort (i.e., a longer collection time period) could have been exerted to collect more fish from these sample reaches; however, this was not done to maintain comparability with the collection time period used for the reference reach (CAR004). These sampling conditions may have had the effect of *underestimating* the number of fish actually present along the LVR reaches adjacent to the Site.

Though fish were collected in greater abundance from CAR004 than the other reaches, the relative abundance of two species, Northern hog sucker (n=43 at CAR004) and bluntnose minnow (n=52 at CAR004), accounted for most of the difference in the total counts between the reaches (see Table 3-1 for a summary tabulation of species collected for each reach). In the case of bluntnose minnow, only two individuals were collected at the three downstream stations, while 52 specimens were collected at CAR004 -- and these were collected as a school. CAR004 was identified for its general similarity in habitat to the reaches adjacent to the Site; however, no two stream reaches will ever be identical. There was more aquatic vegetation associated with CAR004, which creates quiescent areas attractive to bluntnose minnow. Conversely, the LVR had a steeper gradient and faster flowing water at the reaches adjacent to the Site, particularly at CAR002 where the gradient was 2.87 percent versus 0.18 percent at CAR004. The lower numbers of fish, primarily of two species, at CAR001-CAR003 is a difference, but by itself does not indicate a material difference in the fish biological integrity of these LVR sample reaches.

IEPA guidance indicates that the fIBI may have reduced accuracy or precision when sample sizes are too low (IEPA, 2000). For this reason, IEPA applies a "rule of thumb" value of 50 fish in a sample needed to support a valid calculation of fish biotic integrity (IEPA, 2000). Additional analysis (resulting in an "adjusted" fIBI score) is recommended in the IEPA protocol for datasets including less than the "rule of thumb" number of fish. Under the protocol, the adjusted fIBI score is calculated by summing the six species-richness metrics and the single pollution tolerance metric, and rescaling the adjusted score to the established 0-60 Integrity Classification scale to allow comparison to unadjusted fIBI scores.

Fish counts at all LVR reaches were greater than 50. However, as a line of evidence as to determine whether the sampling method implemented at the Site (i.e., backpack electrofishing) may have resulted in lower sampling efficiency compared to IEPA methods used comparably sized streams, the fish data for the LVR reaches were subjected to the adjusted fIBI calculation. The adjusted fIBI scores for each of the LVR reaches are as follows: 36 (CAR001), 37 (CAR002), 34 (CAR003), and 37 (CAR004). In all cases, the metrics deleted in the adjusted fIBI calculation resulted in a decrease in the score of roughly the same magnitude. This would seem to indicate that the adjusted calculation was not too sensitive to the number of fish in the individual samples in these data sets. Still, the adjusted fIBI scores are all in Integrity Class 3, and the adjusted scores for the reaches adjacent to the Site are all within 1 to 3 points of the adjusted score for the reference reach, indicating that there is no meaningful difference in biotic integrity between the LVR reaches sampled. This additional calculation provides some uncertainty bound on the comparison of fIBI scores between the reaches adjacent to the Site and the reference reach and confirms that the fish community in the reaches adjacent to the Site is ecologically similar to the fish community in the reference reach.

3.2.7 Additional Fish Community Measures

Because measures of abundance can be affected by sample collection techniques, associated sampling efficiency, habitat influences, and fish behavioral and distribution patterns, fish abundance alone is not a sensitive measure of impairment or enhancement of the fish community. Diversity indices provide important information about community composition and take the relative abundances of different species into account as well as species richness (i.e., number of individual species).

To provide additional "same-stream" comparative measures for evaluating the fish community, two diversity indices were calculated for each river reach: the Shannon-Weiner diversity index (H') (Levinton, 1982) and Simpson's Index of Diversity (D_s) (Simpson, 1949). Of the many biological diversity indices, these two indices are the most commonly reported in the scientific literature and each is presented here to provide additional evidence for consideration in the BERA weight-of-evidence analysis.

The Shannon-Wiener diversity index (H') is an index that is used to characterize species diversity in a community accounting for both abundance and evenness of the species present (how equal the community is numerically). The index is increased either by having additional unique species or by having greater species evenness. Typically the value of the index ranges from 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness). Calculated Shannon-Wiener diversity indices (H') for each river reach sampled are 2.18 (CAR004), 2.24 (CAR003), 2.24 (CAR002), and 2.08 (CAR001). Using this index, two of the LVR reaches adjacent to the Site, CAR002 and CAR003 actually produced slightly higher values of species diversity compared to the reference reach, CAR004.

Statistical variance for each H' was calculated and Student's *t*-test comparisons performed to determine if individual Shannon-Wiener indices calculated for the river reaches along the Site are statistically different from the reference reach. Results indicated no statistical difference between the reference reach and any of the three reaches adjacent to the Site ($p > 0.05$; after Bonferroni correction (Weisstein, 2010)).

Simpson's D_s calculates the probability that two organisms randomly sampled from a community will belong to two different species. The value of the index ranges from 0 to 1, with 1 representing perfect evenness (all species present in equal numbers). Calculated Simpson's diversity indices (D_s) for each river reach sampled are 0.83 (CAR004), 0.88 (CAR003), 0.86 (CAR002), and 0.83 (CAR001). Again, index values for CAR003 and CAR002 are greater than the reference reach value. Though fish were collected in greater abundance from the reference reach (CAR004) than other reaches, the relative abundance of two species: Northern hog sucker (n=43) and bluntnose minnow (n=52) resulted in unevenness in the dataset and a lower Simpson's D_s.

Statistical variance for each D_s was calculated and Student's *t*-test comparisons performed to determine if individual Simpson's diversity indices calculated for the river reaches along the Site are statistically different from the reference reach. Results indicated no statistical differences.

3.2.8 Fish Community Assessment Summary

Although the presence of slag material and municipal/industrial discharges might be expected to negatively affect the ecological health of the LVR fish community, the fIBI scores indicate that the health of the fish community in the LVR reaches adjacent to the Site is comparable to upstream reaches unaffected by activities at the Matthiessen and Hegeler Zinc Company Site. All four sampled reaches of the LVR had fIBI scores within the Class 3 Integrity Class with fIBI scores > 41. Comparative analysis of Shannon-Weiner and Simpson's diversity indices point overall to a fish community of moderate diversity with no statistically significant difference in diversity noted for the river reaches sampled along the Site versus that of the same-stream reference reach. The fIBI scores correlate to a fish community that has somewhat lower than expected biological integrity. The similarity in fIBI scoring between all sample reaches (all scored within 1-2 points of the same-stream reference reach) and the statistically similar diversity indices suggest that fish biological integrity of the communities in reaches adjacent to the Site is not meaningfully different than the integrity of the community at the upstream reference location, which is un-impacted by the Site.

3.3 Aquatic Macroinvertebrate Community Assessment

Composite, multi-habitat samples of the aquatic macroinvertebrate community were collected at sample reaches CAR001, CAR002, CAR003, and CAR004 during 11–13 August 2009. As previously indicated, each LVR sample reach adjacent to the Site was divided in half, longitudinally, along the river thalweg. Therefore, two composite samples (designated as east and west) were obtained at sample reaches CAR001, CAR002, and CAR003. To remain consistent in sampling procedures, the reference reach (CAR004) was also separated into two composite samples for the east and west halves of the LVR. Therefore, a total of eight 20-jab composite samples were collected during the biological assessment. Please refer to Figure 2-1 for approximate locations of sampling reaches. The raw macroinvertebrate laboratory data are provided in Appendix D. These data were subsequently processed in accordance with IEPA (2008b) standardization procedures and are presented in the following text. All references to taxa in the following discussion are at the genus level unless otherwise noted.

3.3.1 Sample Reach CAR001

East Bank

Species richness at CAR001-East Bank (CAR001East) was represented by 30 taxa and 357 organisms (Table 3-11). In ranked order of abundance, the four most dominant families of organisms at CAR001East were Hydropsychidae (caddisflies), Chironomidae (midges), Elmidae (riffle beetles), and Simuliidae (black flies). Caddisflies were the most dominant group represented accounting for 46 percent of the sample. The single most dominant species at CAR001East was *Cardiocladius obscurus* (midge) and *Ceratopshyche morosa* (caddisfly), respectively. Five functional feeding groups were represented at CAR001East, with Predators, Collector/Filterers, and Shredders containing seven, six, and five taxa, respectively. Seven Collector/Gatherers taxa were identified and Scrapers were represented by two taxa.

<u>West Bank</u>

Originally, a total of 437 organisms were identified in the macroinvertebrate sample for Station CAR001-West Bank (CAR001West). To comply with IEPA's subsampling/sorting procedures (preferred sample size of 300 organisms; +/- 20 percent), the sample was reduced using a random number generator/surrogate method, as preferred by IEPA. This process led to a final 304-organism sample (Table 3-12). Species richness was represented by 42 taxa. In ranked order of abundance, the four most dominant families of organisms at CAR001West were Hydropsychidae (caddisflies), Chironomidae (midges), Elmidae (riffle beetles), and Simuliidae (black flies). Hydropsychidae were the most abundant group, accounting for 39 percent of the sample. The single most dominant organism at CAR001West was the caddisfly, *Cheumatopsyche sp.* (50 individuals). Five functional feeding groups were represented in the sample from CAR001-West including Predators, Collector/Filterers, Collector/Gatherers, Shredders, and Scrapers. Predators at CAR001West dominated functional feeding groups with a total of 11 taxa. Scrapers were the least represented feeding group at this location, containing five taxa.

The most notable observation at CAR001 (East and West) was the paucity of Ephemeroptera (mayfly) taxa in the samples.

3.3.2 Sample Reach CAR002

<u>East Bank</u>

The CAR002-East Bank (CAR002East) sample consisted of 313 organisms represented by 39 taxa (Table 3-13). The four most dominant families of organisms at CAR002East were Chironomidae (midges), Elmidae (riffle beetles), Hydropsychidae (caddisflies), and Aeshnidae (darners). Chironomids were the most dominant group represented accounting for 38.6 percent of the sample. The most dominant species at CAR002East was *Dubiraphia vittata*, a riffle beetle. Five functional feeding groups were represented at CAR002East including Collector/Filterers, Collector/Gatherers, Scrapers, Shredders, and Predators. The dominant functional feeding group was Predators with 12 taxa. Scrapers were represented by two taxa.

<u>West Bank</u>

A total 314-organism sample was identified for the CAR002-West Bank (CAR002West) location represented by 30 taxa (Table 3-14). In ranked order of abundance, the four most dominant families of organisms at CAR002West were Hydropsychidae (caddisflies), Chironomidae (midges), Hydroptilidae (caddisflies), and Simuliidae (black flies). Hydropsychids were the most dominant group accounting for 52.5 percent of the sample. The most dominant species at CAR002West were both caddisfly species, identified as *Cheumatopsyche sp.* and *Ceratopsyche morosa*. Five functional feeding groups were represented at CAR002West including Collector/Filterers, Collector/Gatherers, Scrapers, Shredders, and Predators. The dominant functional feeding group was Collector/Filterers with nine taxa. Scrapers were the least abundant of the functional feeding groups, consisting of three taxa.

3.3.3 Sample Reach CAR003

East Bank

A total of 566 organisms were identified in the initial subsorting/sampling effort for CAR003-East Bank (CAR003East). Per IEPA protocol, this subsample was reduced via the random number generator/surrogate method to reduce the number of organisms to within 20 percent of 300. Therefore, the final subsample for metric scoring included 321 organisms represented by 33 taxa (Table 3-15). The four most dominant families of organisms at CAR003East were Hydropsychidae (caddisflies), Chironomidae (midges), Baetidae (mayflies), and Elmidae (riffle beetles). Hydropsychids were the most dominant group represented accounting for 33.3 percent of the sample. The most dominant species at CAR003East was the *Hydropsyche sp.*, a caddisfly genus. Five functional feeding groups were represented at CAR003East including Collector/Filterers, Collector/Gatherers, Scrapers, Shredders, and Predators. The functional feeding groups for this location were evenly distributed with the dominant group being Predators (eight taxa) and the least dominant group being Shredders (four taxa).

West Bank

The CAR003-West Bank (CAR003West) included a 341-organism sample represented by 45 taxa (Table 3-16). The four most dominant families of organisms at CAR003West were Hydropsychidae (caddisflies), Chironomidae (midges), Elmidae (riffle beetles), and Hydroptilidae (caddisflies). Hydropsychids were the most dominant group represented accounting for 37 percent of the sample. The most dominant species at CAR003West was the *Cheumatopsyche sp.*, a caddisfly genus. Five functional feeding groups were represented at CAR003West including Collector/Filterers, Collector/Gatherers, Scrapers, Shredders, and Predators. The dominant functional feeding group was Predators with 10 taxa. The remaining taxa were relatively evenly distributed among the other functional feeding groups.

3.3.4 Sample Reach CAR004 (Reference)

East Bank

A total of 335 organisms and 40 taxa were identified in the sample for CAR004-East Bank (CAR004East) (Table 3-17). As such, data reduction was not necessary. The four most dominant families of organisms at CAR004East were Hydropsychidae (caddisflies), Chironomidae (midges), Baetidae (small mayflies), and Heptageniidae (flat-headed mayflies). Hydropsychids were the most dominant group accounting for 25.7 percent of the sample. The most dominant species at CAR004East was *Ceratopsyche morosa*. Five functional feeding groups were represented at CAR004East including Collector/Filterers, Collector/Gatherers, Scrapers, Shredders, and Predators. Scrapers (10 taxa) represented the most common functional group, while Shredders (three taxa) were the least common.

West Bank

The CAR004-West Bank (CAR004West) included a 351-organism sample represented by 43 taxa (Table 3-18). The four most dominant families of organisms at CAR004West were Chironomidae (midges), Hydropsychidae (caddisflies), Elmidae (riffle beetles), and Baetidae (mayflies). Chironomids were the most dominant group represented accounting for 28.5 percent of the sample. The most dominant species at CAR004West was the *Ceratopsyche morose,* a species of caddisfly. Five functional feeding groups were represented at CAR004West including Collector/Filterers, Collector/Gatherers, Scrapers, Shredders, and Predators. The dominant functional feeding group was Collector/Gatherers with 16 taxa. The functional feeding group with the least amount of taxa represented was Shredders (four taxa).

3.3.5 Freshwater Mussels

Mussel surveys yielded only one live mussel specimen at each of the four sample reaches surveyed. Plain pocketbook was collected at the slag pile locations (CAR001, CAR002, and CAR003); one specimen of ellipse was collected at the reference reach (CAR004). Additional relict shells were also observed, although scattered in occurrence. Relict shell species included plain pocketbook, white heelsplitter (*Lasmigona complanata*), fragile papershell (*Leptodea fragilis*), giant floater (*Pyganodon grandis*), and ellipse.

Although there was a paucity of mussel species and abundance observed during the current assessment, similar findings were noted during the Illinois Natural Heritage Survey (INHS) mussel surveys of the LVR during collection events conducted in summer 2009 (INHS, 2009). The INHS conducted two mussel surveys approximately 1 river mile upstream of CAR004 on 21 July 2009, and 13 August 2009. These surveys averaged 3.5 man-hours. The 13 August 2009 survey identified three live plain pocketbook specimens. The 21 July 2009 event observed three dead mussels and five relict specimens. Refer to the table below for information on the total number and species identified during the mussel surveys conducted by INHS.

Survey Results for INHS Mussel Survey on 21 July 2009 and 13 August 2009

Species	Number Observed	Condition*	Date Observed
Cylindrical papershell (*Anodontoides ferussacianus*)	1	D	21 July 2009
Creek heelsplitter (*Lasmigona compressa*)	1	R	21 July 2009
Giant floater (*Pyganodon grandis*)	1	D	21 July 2009
Creeper (*Strophitus undulatus*)	1	R	21 July 2009
Plain pocketbook (*Lampsilis cardium*)	1	D	21 July 2009
Plain pocketbook (*Lampsilis cardium*)	3	L	13 August 2009
Fatmucket (*Lampsilis siliquoidea*)	1	R	21 July 2009
Ellipse (*Venustaconcha ellipsiformis*)	2	R	21 July 2009

*D=Dead; L=Live; R=Relict

3.3.6 Macroinvertebrate Index of Biotic Integrity (mIBI)

Seven individual macroinvertebrate metrics were scored for each LVR sample reach (east and west; Tables 3-19 through 3-26). To clarify, an mIBI score was determined for both east and west portions of each river reach surveyed. More than 300 organisms were collected at each east and west portion of the sample reaches and in two cases (both adjacent to the Site), so many organisms were collected that data reduction was necessary to conform with IEPA's 300 organism (+/- 20 percent) sample size specification. An important point to be made from this circumstance is that the macroinvertebrate community in the LVR was abundantly represented at each of the river reaches surveyed.

The seven metric values for each sample reach (east and west) were assigned a standardized metric score based on the percentage of the IEPA best metric value (IEPA, 2008b). The seven individual, standardized metric values were averaged to yield a total mIBI score and then ranked into the appropriate IEPA biotic Integrity Class. The mIBI results and total scores for each river reach (east and west portions) are discussed in the following subsections and summarized in Table 3-27.

The IEPA considers (along with other factors) the mIBI in conjunction with the fIBI in making assessments of designated use attainment in streams pursuant to the Clean Water Act. If the mIBI is unavailable, the fIBI may be considered along with the MBI, which is a component of the mIBI, in making preliminary use attainment assessments. In that regulatory context, if a stream attains an fIBI score of $\geq$ 41 combined with an mIBI score of $\geq$ 41.8 (or an MBI score $\leq$ 5.9, if the mIBI is unavailable), the stream would be given a preliminary assessment that it is "Fully Supporting" of aquatic life use in Illinois streams. Under the Clean Water Act, IEPA equates the "Fully Supporting" terminology to a conclusion that a stream has "No Impairment" and is indicative of good resource quality (IEPA, 2008a). While this bioassessment was undertaken in a different regulatory context (i.e., as part of a CERCLA site BERA), comparison of Site values to the values derived from the Clean Water Act should provide useful insight on the overall ecological health of the aquatic community in the LVR. Therefore, an mIBI score $\geq$41.8 and an MBI score $\leq$ 5.9 are utilized as benchmarks for evaluating impacts to the aquatic macroinvertebrate community.

CAR001

Located along the downstream end of the slag pile, CAR001East and CAR001West received mIBI scores of 53.7 and 63.9 points, respectively; each considered Integrity Class 2 (biotic integrity similar to that expected in typical Illinois streams (Tables 3-19 and 3-20). The MBI scores for CAR001East and CAR001West (5.2 and 5.4, respectively) were each less than the preliminary assessment value of 5.9 (IEPA, 2008a).

CAR002

CAR002East and CAR002West are situated upstream of CAR001 and similarly adjacent to the OU1 slag pile (Figure 2). These sampling reaches received mIBI scores of 58.3 and 67.0, respectively (Tables 3-21 and 3-22). The resultant mIBI quality description ranks them both within the middle of the Integrity Class 2. CAR002West contained one of the highest scores for Percent Ephemeroptera, Plecoptera, and Trichoptera (EPT), with 66.2 percent of the organisms belonging to one of these three orders; the presence of which reflect good water quality. As with CAR001, both CAR002 East (5.4) and CAR002West (5.0) had MBI scores less than 5.9.

CAR003

CAR003East and CAR003West are located at the northern edge of the slag pile and just downstream of the City of LaSalle CSO and the ASO discharges from OU2. Similar to the previously discussed samples, CAR003East and CAR003West both exhibit a low MBI (4.8 and 5.2, respectively), indicating good water quality. The final mIBI scores total 79.4 for CAR003East and 83.3 for CAR003West, respectively, ranking these sample locations in Integrity Class 1, which is described as biotic integrity higher than expected in typical Illinois reference streams (Tables 3-23 and 3-24).

CAR004

The reference reaches (CAR004East and CAR004West) also scored high mIBI values and relatively low MBI values (Tables 3-25 and 3-26). Sample data from CAR004East rated an mIBI score of 77.0 and an MBI of 5.2, while CAR004West rated an mIBI score of 81.8 and an MBI score of 5.1. As such, both of these sample locations rank in Integrity Class 1.

3.3.6.1 *Comparison of mIBIs Between River Reaches*

Unlike for the fIBI, IEPA guidance available at the planning stages of this bioassessment did not include a statistically-based precision estimate or score/point range upon which a determination of "no difference" could be made when comparing mIBI scores for different sites within the same stream (IEPA, 2008b). IEPA's draft Facility Related Stream Survey Standard Operating

Procedure (the Draft FRSS), dated 11 August 2010, describes how to "collect aquatic macroinvertebrate samples from wadeable streams and small rivers in order to evaluate chemical impacts downstream from point-source discharges" (IEPA, 2010). Section 6.3 of the Draft FRSS specifies the collection of macroinvertebrates from matched habitats that co-occur at monitoring sites upstream and downstream of the point-source discharge and the segregation of the macroinvertebrates by the habitats from which they were collected. The macroinvertebrate samples for the LVR reaches sampled during the bioassessment for this Site were not segregated by the habitat types identified in the field; rather, they were composited in accordance with the mIBI protocol (IEPA, 2008b). However, the Draft FRSS provides that when matched-habitat and pair-wise comparisons are unavailable, a composite sample collected from all habitats encountered at a site may be used for the FRSS evaluation; although noting that habitat differences implicit in the samples may confound the result (IEPA, 2010). Given the Draft FRSS's emphasis on the desirability of matched or comparable habitats, the application of this procedure to the composite data collected during the bioassessment of the LVR may not provide meaningful results. Still, we have attempted to apply the guidance to the extant data.

Following the Draft FRSS protocol, MBI values, species richness and some other macroinvertebrate community attributes for samples collected along the Site river reaches were compared to the corresponding values for the upstream (same-stream) reference reach. To assist in interpretation of the data, the protocol provides narrative categorical definitions of "FRSS Stream Impairment"; two applicable to this discussion are provided in the table below.

IEPA Definition of FRSS Stream Impairment (IEPA, 2010)

DESCRIPTORS	DEFINITION
No Impact Good Full Use Support Balanced	No significant modification of aquatic community structure and function (<10%). Community within expectations for stream size and physiographic region or natural division. MBI usually <6.0 or there is No increase in MBI above the background site. Professional judgment may be used in determining the extent of community deterioration and may result in altered classifications.
Minor Impact Fair Partial/Minor Use Support Slightly Impaired	Some modification of aquatic community apparent, resulting in 10-25% decline in species richness, intolerant forms, numbers of individuals or applicable biotic index values; similar increase in number of non-sensitive forms may be evident. MBI values generally range from 6.0-7.5 or an increase in MBI values of <1.5 units above background is observed. Professional judgment may be used in determining the extent of community deterioration and may result in altered classification.

The bullets below represent the attempted application of these definitions to the macroinvertebrate data for the LVR reaches:

- Species richness for two of the six river samples collected along the Site (CAR001West and CAR002West) was marginally more than 10 percent different from the corresponding reference reaches; 13.4 percent and 10.5 percent, respectively. Notably, CAR001West was subject to a data reduction procedure to meet IEPA mIBI protocol sample-size requirements. While the data reduction and other standardization measures may be justified for the mIBI evaluation to assure data collected in the field are appropriately comparable to the IEPA best metric value database, such measures are unspecified in the Draft FRSS protocol and believed unnecessary. The data reduction procedure artificially reduced the number of individuals from 437 to 304 individuals, thus biasing the initial comparative analysis. In reality, the abundance of macroinvertebrates at CAR001West exceeded that for the corresponding same-stream reference by 86 organisms. Further, if assuming other aspects of the data standardization process applicable to the mIBI calculations are not applicable to the FRSS evaluation, CAR002West drops from a 10.5 percent to a 9.8 percent difference in species richness when compared to the corresponding reference reach. As based on the IEPA standardized dataset, species richness for all other sample reaches were less than 10 percent different from the corresponding reference reaches.

- The number of intolerant taxa present in sampling reaches adjacent to the Site seemed overall somewhat better than at the same-stream reference reach. The numbers of intolerant taxa at CAR004 were 7 (east) and 8 (west) compared to IEPA's mIBI-based best metric value (9 taxa). In contrast, four of the six sampling reaches adjacent to the Site had 9 or more intolerant taxa, and only one (CAR001East) had fewer intolerant taxa (n=6) than the number collected at CAR004.

- Based on mIBI scores, Integrity Class rankings indicated all LVR sample reaches had biotic integrity similar to or higher than expected for typical Illinois reference streams. The mIBI scores for samples collected at CAR001 and CAR002 were notably lower than the mIBI scores at the same-stream reference reach. However, mIBI scores for CAR003, which is also adjacent to the Site, were marginally higher than those at the reference reach.

- The MBIs for the reference reach were 5.2 at CAR004East and 5.1 at CAR004West. Accordingly, a 10 percent variation for these values would be 0.5 units. MBI values for all sampled LVR reaches were below 6.0, with the highest MBI value along the Site (5.4 at CAR001West and CAR002East) only 0.3 units higher than the same-stream reference reach values. This increase is much less than 1.5 units included in the above definitions as being indicative of minor impact. In addition, the MBI values of the other four reaches adjacent to the Site were less than or essentially equivalent to the CAR004 values. The average MBI value for all reaches along the Site was 5.16, while the average MBI for the same-stream reference reach was 5.15.

Some individual attributes of the LVR macroinvertebrate community along the Site do not consistently compare well with the similar attributes of the same-stream reference reach (e.g., number of Ephemeroptera taxa and percent scrapers; primarily for samples at CAR001 and CAR002). Some of these results are qualitatively discussed further in Section 3.3.8. Many other individual attributes compare favorably and would seem to justify a No Impact conclusion in the Draft FRSS terminology. The Draft FRSS does not seem to provide any systematic way to aggregate these different comparisons into an overall conclusion, which makes it difficult to apply to the LVR data.

3.3.6.2 ***mIBI Uncertainty***

The primary source of uncertainty associated with the macroinvertebrate community assessment is related to the allocation of the IEPA-specified 20 jabs/dips. Habitat differences have been shown to impact macroinvertebrate community structure (Wang *et al.*, 2006; Stepenuck *et al.,* 2008; Colas *et al.,* 2011). The difference in the method of allocating the 20 jabs/dips for this project and the method specified in the IEPA (2007) protocol was explained in Section 2.4 and the impact of the different methodology on the ratio of bank-zone to bottom-zone samples collected was described in Section 3.1.2.

To evaluate the potential impact of data collection methods on the mIBI comparisons, Geosyntec further reviewed the IEPA's protocol and the sampling methods used to develop the mIBI best metric values. Unfortunately, the method of sampling used to develop the mIBI best metric values is unclear. Representatives of IEPA's Bureau of Water indicated that when applying the best metric values for Clean Water Act purposes, they operate on the assumption that the data underlying the mIBI best metric values was collected in accordance with the 2007 protocol. But, the Tetra Tech reports (2004; revised 2007) prepared under contract with IEPA indicate that the sampling supporting the best metric value development was performed in 2001 and that the individual jabs for that sampling effort were distributed among the habitats in proportion to their occurrence in the sampled stream segment. This description seems similar to the method used for allocating the individual jabs for the sampled reaches of the LVR.

Given this uncertainty, Geosyntec further reviewed the Tetra Tech reports. One objective of the report was to evaluate whether the 20-jab method could be used reliably in Illinois and to establish a cross-calibration for comparison of historical data that were sampled with the "handpick method" for macroinvertebrate sampling. Tetra Tech described the handpick method as "primarily a qualitative collection method" involving the collection of organisms "with a sieve from all available habitats," sorting of taxa "in the field until no new taxa were evident to the field collector," and the submission of all organisms to the laboratory for identification. According to the Tetra Tech report, the macroinvertebrate sampling handpick method had "the potential for bias among collectors due to the potential uneven field collection efforts and numbers and types of organisms collected…."

To compare the handpick and 20-jab methods, IEPA (in 2001) collected macroinvertebrate samples at 135 sites using both methods. Data analysis of these samples showed little dissimilarity between methods; however, the 20-jab method did slightly increase the discrimination ability (i.e., the ability to identify stressed sites "correctly"). Thus, although the handpick and IEPA (2007) 20-jab collection techniques are not directly comparable methods, the Tetra Tech (2004) report suggests the two methods would likely produce similar results regarding the status of the macroinvertebrate community. Given that the differences between the 20-jab sample allocation used by Geosyntec and the 20-jab sample allocation per IEPA 2007 protocol are minor when compared to the differences between the handpick method and any 20-jab method, the potential impacts to the results and conclusions of the macroinvertebrate community assessment are likely to be minor. Based on the above, the comparison of Site mIBI metrics determined for the east and west halves of each LVR reach to IEPA best metric values is considered to provide one line of evidence that is useful in evaluating the overall health of the macroinvertebrate community. Additional lines of evidence, which further reduce uncertainty associated with the results of the mIBI, are presented in the following sections.

3.3.7 Additional Macroinvertebrate Community Measures

As discussed in the previous section, the uncertainty as to the macroinvertebrate sampling methods underlying IEPA's mIBI best metric values and the different sampling method used for this project compared to the IEPA 2007 protocol introduced some level of uncertainty into the comparison with IEPA mIBI best metric values. Therefore, similar to the fish community assessment, two diversity indices were calculated for each LVR sample reach to provide an additional comparative measure for evaluating the macroinvertebrate community: the Shannon-Weiner diversity index (H'), and Simpson's Index of Diversity (D_s). The mIBI analyses discussed above counted macroinvertebrate taxa at the genus level in accordance with IEPA protocol to allow comparability to IEPA's mIBI metric best metric values. Similar treatment (i.e., genus level evaluation) of the data was not necessary or appropriate for same-stream analysis by Shannon-Weiner and Simpson's diversity indices. As such, these indices were calculated based on the standardized data sets for each sample reach (i.e., Hemiptera excluded, etc.), but considering taxa at the species level. These analyses provide additional information for consideration under the BERA weight-of-evidence approach and reduce uncertainty associated with the results of the mIBI comparisons discussed in the previous section.

The Shannon-Wiener diversity index (H') characterizes species diversity in a community accounting for both abundance and evenness of the species present. The index is increased either by having additional unique species or by having greater species evenness. Typically the value of the index ranges from 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness). Calculated Shannon-Wiener macroinvertebrate community diversity indices (H') for each river reach sampled are provided below.

Shannon-Wiener Macroinvertebrate Diversity Indices (*H'*)

Sample Reach	East	West
CAR001	2.70	3.03
CAR002	3.17	2.73
CAR003	2.99	3.11
CAR004	3.12	3.26

Shannon-Wiener H' values were greatest at the reference reach CAR004West, and least at reach CAR001East. Values along the west half of the LVR were greater than along the east half at two of the three sample reaches adjacent to the Site (CAR001 and CAR003) and at the reference reach (CAR004). The Shannon-Wiener H' value for CAR002West was lower than CAR002EAST; however, CAR002East also exceeded the H' value for the east side of the reference reach. Considering a maximum theoretical H' value of 3.5, the LVR macroinvertebrate community exhibits moderate to high species richness and evenness based on the river reaches sampled and, overall, there appears to be little difference in species richness and evenness between the east and west halves.

Statistical variance for each H' was calculated and Student's *t*-test comparisons performed to determine if individual Shannon-Wiener indices calculated for the east and west portions of river reaches along the Site are statistically different from the corresponding portions of the reference reach. Results indicated no statistical difference for CAR001West, CAR002East, CAR003East and CAR003West. Statistical difference was noted between the reference reach and CAR001East and CAR002West.

As presented previously, Simpson's D_s calculates the probability that two organisms randomly sampled from a community will belong to two different species. The value of the index ranges from 0 to 1, with 1 representing perfect evenness (all species present in equal numbers). Calculated Simpson's macroinvertebrate community diversity indices (D_s) for each river reach sampled are provided below.

Simpson's Macroinvertebrate Diversity Indices (D_s)

Sample Reach	East	West
CAR001	0.90	0.93
CAR002	0.93	0.90
CAR003	0.93	0.93
CAR004	0.93	0.94

Simpson's D_s values were generally comparable for all river reaches sampled; and, indicate a macroinvertebrate community of generally high species richness and evenness. The Simpson's D_s values for the east and west halves of the LVR were similar to those at CAR003 and CAR004. While the value for CAR002West was less than for CAR002East, the exact reverse was true for

CAR001. Thus, overall, the Simpson's D_s values were not materially different for the side of the LVR immediately adjacent to the Site (west) and the opposite side of the LVR.

Statistical variance for each D_s was calculated and Student's *t*-test comparisons performed to determine if individual Simpson's diversity indices calculated for the east and west portions of river reaches along the Site are statistically different from the corresponding portions of the reference reach. Results were the same as for the Shannon-Wiener H' analysis with no statistical difference noted for CAR001West, CAR002East, CAR003East and CAR003West. Statistical difference was noted between the reference reach and CAR001East and CAR002West.

Overall, no statistical difference in macroinvertebrate community diversity (i.e., considering species richness and evenness) was determined for four of the six LVR sample reaches adjacent to the Site when compared to the corresponding reference sample reaches.

Summary of Macroinvertebrate Shannon-Wiener *H'* and Simpson's *Ds*

Sampling Station	Shannon-Wiener Diversity Index (H')		Simpson's Index of Diversity (D_S)	
	H'	p-value	D_S	p-value
CAR001E	2.70	3.02E-06	0.90	1.86E-03
CAR001W	**3.03**	**> 0.05**	**0.93**	**> 0.05**
CAR002E	**3.17**	**> 0.05**	**0.93**	**> 0.05**
CAR002W	2.73	4.45E-08	0.90	5.01E-04
CAR003E	**2.99**	**> 0.05**	**0.93**	**> 0.05**
CAR003W	**3.11**	**> 0.05**	**0.93**	**> 0.05**
CAR004E-ref	3.12	---	0.93	---
CAR004W-ref	3.26	---	0.94	---

Bolded values indicate no statistical difference from reference ($p > 0.05$; after Bonferroni correction).

3.3.8 Macroinvertebrate Community Assessment Summary

Macroinvertebrate scores for the LVR sample reaches adjacent to the Site were somewhat variable, but generally reflected a healthy and balanced macroinvertebrate community at least comparable in biotic integrity to that expected for similar Illinois streams. All of the sampled LVR reaches had mIBI scores classified as Integrity Class 1 (higher than expected biotic integrity) or Class 2 (biotic integrity similar to that expected). Reaches CAR003 East and CAR003 West (which are adjacent to the north edge of the slag pile and just downstream of the CSO and ASO) actually had Integrity Class 1 mIBI scores that were slightly higher than the reference reaches at CAR004. Reaches CAR001 and CAR002, both adjacent to the slag pile, did have mIBI scores that were on average about 20 points lower than the LVR reaches at CAR003 and CAR004. Also, Shannon-Weiner and Simpson's diversity index calculations show statistically significant variations in species diversity for CAR001 East and CAR002 West when compared to the reference reaches, but show no statistical difference between the reference reach and the other four LVR sample reaches adjacent to the Site. Given the split-river design conducted at the request of U.S. EPA, it is also worth noting that the west portions of each sample reach scored higher mIBIs (from about 4 to 10 points higher) than the corresponding east portions. This is also true for the diversity indices, except at CAR002.

Despite the presence of slag material along and within the river channel at CAR001 through CAR003, the total number of taxa (at the genus level) observed for some east/west river reach portions (CAR001West, CAR002East, and CAR003West) scored within 85 percent or higher of IEPA's best metric value of 46 taxa. The other reaches adjacent to the Site had total taxa between about 65 to 70 percent of IEPA's best metric value. Further, the number of intolerant taxa (representing the sixth metric) scored equal to or above IEPA's best value (9 taxa) in four of the six sampling reaches adjacent to the Site. And, the MBI values for each sampled LVR reach were below 5.9, which is a value used by IEPA (in combination with fIBI values) to preliminarily assess attainment of aquatic life use in the absence of full mIBIs. Table 3-27 provides a summary of each sampling reach, including individual metric scores and their cumulative, standardized mIBI scores.

Metrics that contributed the most to the relatively lower mIBI scores in sampling reaches CAR001 and CAR002 were the Number of Ephemeroptera Taxa and Percent Scraper. The presence of mayflies was noticeably diminished or absent in these sampling reaches and the lack of these taxa also had an effect on the lower values for Percent Scraper (many mayfly taxa are known to fall within the scraper functional feeding group). Although mayflies are a large order and there is wide variation in habitat and food preferences, research indicates that mayflies (particularly Heptageniidae) are generally more intolerant of heavy metal concentration than other macroinvertebrate taxa (Clements *et al*, 2000; Cain et al, 2003). However, certain sample reaches adjacent to the slag pile contain relatively similar numbers of Ephemeroptera taxa to those of the reference reach [CAR003West – 6 taxa; CAR003East – 5 taxa; CAR004East and CAR004West (reference reach) each yielded 6 taxa]. In addition, sampling reaches CAR003East and West were both comparable to the reference reaches for the Percent Scraper metric. As such, any affect metals concentrations may have on the paucity of Ephemeroptera taxa sampled at CAR001 and CAR002 is inconclusive. Both CAR001 and CAR002 received slightly lower QHEI scores (74 and 79, respectively) compared to CAR003 (83) and reference reach CAR004 (84), although all the habitat scores were relatively high. Thus, habitat influences on macroinvertebrate community structure cannot be excluded as a factor in the lower mIBI scores calculated for these river reaches. Potential risks to macroinvertebrates in the context of other LVR data will be further evaluated in the Final BERA. Specifically, the BERA will evaluate the overall status of the macroinvertebrate community using a weight-of-evidence approach that integrates results of the community assessment presented herein with the sediment toxicity tests and whole sediment chemistry data.

3.4 Discussion of Combined Fish and Macroinvertebrate Community Assessment Results

This bioassessment was undertaken as part of a weight-of-evidence evaluation of ecological risks and the ecological health of the LVR to support a BERA for the LVR in accordance with U.S. EPA guidance under CERCLA. The bioassessment collection activities and the resulting calculation of indices of biotic integrity for fish and macroinvertebrate communities were undertaken in general accordance with an approved FSP and the Technical Approach Consensus Document (Geosyntec, 2009). The IBI assessment framework utilized to evaluate the LVR fish and macroinvertebrate communities in the current study was generally based on protocols developed by IDNR and IEPA to assess progress towards and achievement of Clean Water Act goals pertaining to designated use support for Illinois surface waters. While the current bioassessment was conducted to address CERCLA issues and is not intended to be a full designated use assessment under the Clean Water Act, comparison of the IBI results to benchmark values set by IEPA should provide some useful evidence to be considered in the CERCLA BERA.

IEPA considers biological information, primarily fIBI, mIBI and MBI data, physicochemical water data, and physical-habitat information in making designated use assessments under the Clean Water Act (IEPA, 2008a).

> "For assessing attainment of *aquatic life* use in streams, direct reliance on information-rich biological indicators over indirect and sometimes simplistic comparisons of physicochemical water quality criteria is a useful and widely recommended approach [citations omitted]. Much more than physicochemical water data, biological indicators—such as a fish Index of Biotic Integrity—provide direct, reliable measures of aquatic-community health and facilitate detection of cumulative impacts on aquatic life from multiple stressors [citation omitted]. By relying more on biological indicators than on less-reliable surrogates (e.g., water chemistry), our assessments of *aquatic life* use achieve their primary purpose: to determine the degree to which a water body provides for the protection and propagation of fish, shellfish, and wildlife (i.e., the Clean Water Act's interim aquatic life goal)."

In making use attainment determinations, IEPA reaches one of two possible conclusions for each water body and designated use: Fully Supporting the designated use, which is also described as having good resource quality, or Not Supporting the designated use, which is also referred to as having fair or poor resource quality. In this context, IBIs are divided into three ranges: no impairment, moderate impairment and severe impairment. The IBI values identified by IEPA as showing no impairment are as follows: (1) fIBI $\geq$ 41; (2) mIBI $\geq$ 41.8, and (3) MBI $\leq$ 5.9, when the mIBI is unavailable (IEPA, 2008a). Recognizing the greater information value of biological indicators, IEPA "typically conclude[s] *Fully Supporting* for situations in which two biological indicators indicate lack of impairment, despite any contraindication from surrogate data (see cells 1A and 4A in Table C-1)" (IEPA, 2008a). Thus, for a given stream, if the fIBI and mIBI (or the MBI if the mIBI is not available) are both in a range showing no impairment of aquatic life use, this yields a preliminary assessment conclusion of Fully Supporting, which is indicative of good resource quality (Table C-1 of IEPA, 2008a).

Within this framework, the IBIs developed for the LVR sample reaches in this bioassessment can be compared to IEPA's benchmarks. As set forth above and summarized on Table 3-10, the fIBI values for all sample reaches of the LVR exceed 41, ranging from 44 at the reference reach to 42 at CAR003, which is adjacent to the northern portion of the slag pile and just downstream of the City of LaSalle CSO and the ASO. The mIBIs for the east and west halves of the sample reaches all exceed 41.8, ranging from 83.3 at CAR003West to 53.7 at CAR001East, which is at the southern end of the slag pile (see Table 3-27). While the mIBIs were calculated under a modified application of IEPA's protocol, the values are still considered representative of macroinvertebrate ecological health of the sample reaches and comparable to the IEPA benchmarks in providing perspective for the current study. Even if the mIBI is considered unavailable, the MBIs for the east and west halves of the sample reaches are all less than 5.9, ranging from 4.8 at CAR003East to 5.4 at CAR002East and CAR001West (see Table 3-27). Thus, in accordance with the IEPA guidance, the combination of the fIBI and mIBI data, or the MBI data if the mIBI is deemed unavailable, supports a preliminary conclusion that aquatic life use is fully supported in the sampled reaches of the LVR and is indicative of good resource quality. This analysis should provide some useful evidence in the context of the weight-of-evidence evaluation for the BERA in accordance with U.S. EPA ecological risk assessment guidance (EPA, 1997).

3.5 Fish and Mussel Tissue Analysis

The results of the fish tissue analysis indicate generally similar concentrations of metals within both forage/prey species and predatory/sportfish species tissue across the sample reaches. However, overall metal concentrations are relatively higher in reaches CAR001 and CAR002. The only exceptions include silver concentrations in the sportfish whole body composite sample, which were highest at CAR004 (Reference reach), and copper concentrations for prey whole body composite sample, which were highest at CAR003. Metal concentrations (for all analytes) in mussel species are noticeably higher than in fish species. However, these differences may be attributed to the presence of metal-bearing sediment within the mussel tissue samples, as these organisms are filter feeders and inhabit the sediment substrate within the river channel. The mussels were not intentionally depurated prior to analysis. Therefore, these numbers may be exaggerated from actual metal concentration in mussel tissue. Refer to Table 3-28 for results of the biotic tissue analysis. These data will be evaluated in greater detail as part of the weight-of-the evidence approach to the BERA being conducted for OU1 in Section 4 of the Risk Assessment.

4.0 SUMMARY AND CONCLUSIONS

A biological assessment of the LVR was conducted 11-13 August 2009. The assessment was conducted to evaluate potential impacts to the aquatic community possibly associated with the Matthiessen and Hegeler Zinc Company Site and to support the BERA being conducted for OU1 under the CERCLA regulatory framework.

4.1 Biological Assessment Summary

Four sampling reaches were established in the LVR. Two were located along the middle and southern portion of the OU1 slag pile. Another was located along the northern edge of the slag pile and just downstream of the City of LaSalle CSO and the ASO. The fourth reach was located upstream and outside any influence of the Matthiessen and Hegeler Zinc Company Site. The fish community was sampled at these four river reaches. The east and west halves of these four reaches (for a total of eight sample locations) were sampled for the macroinvertebrate community assessment in compliance with the split-river design requested by U.S. EPA. Aquatic habitat assessments were conducted using established protocols (QHEI) to qualitatively evaluate habitat similarity among sample locations and minimize potential bias in the biological data set for each reach. Based on available information, the current study appears to be the first and most comprehensive biological assessment conducted in the LVR reach adjacent to the Site.

Assessment of the fish and macroinvertebrate communities was generally guided by IDNR and IEPA sampling procedures. As described in detail above, all aspects of the IEPA's macroinvertebrate collection protocol were not followed, but the collection procedures used in the current study were consistently applied at all LVR reaches (including the reference reach). Resultant data were analyzed using established IDNR and IEPA protocols for multi-metric assessments to obtain indices of biotic integrity for the fish (i.e., fIBI) and macroinvertebrate (i.e., mIBI) communities for use as benchmark to compare between reaches.

In addition to the multi-metric biological assessment, fish and mussel tissue samples were collected during field sampling activities to support the OU1 BERA and HHRA.

4.2 Study Conclusions

This biological assessment clearly demonstrates that aquatic life is present in the LVR adjacent to the Matthiessen and Hegeler Zinc Company Site. Additionally, the biotic integrity of fish and macroinvertebrate communities in the sampled reaches of the LVR adjacent to and near the Site, as indicated by the multi-metric biological assessment, is reflective of a generally healthy aquatic community.

The biotic integrity of the fish community as determined from the fIBI scoring indicates that all LVR reaches sampled, including the reference reach, are in IEPA Integrity Class 3 (lower biotic integrity than expected for typical Illinois reference streams) and are ecologically similar. Thus, it is reasonable to conclude that the ecological condition of the fish community in the LVR adjacent to the Site is not meaningfully different from the "background" conditions as measured at the same-stream reference reach, which is not impacted by the Site.

The absolute number of fish collected from two areas adjacent to the Site was near the lower end of what IEPA considers acceptable for fIBI analysis without adjustment; still, the fish counts were all greater than the "rule of thumb" value of 50 that IEPA guidance specifies as the trigger for adjusting the fIBI calculation. However, as a line of evidence to determine whether the sampling method implemented at the Site (i.e., backpack electrofishing) may have resulted in lower sampling efficiency compared to IEPA methods used in comparably sized streams, the fish data for the LVR reaches were subjected to an adjusted fIBI calculation. In all cases, the metrics deleted in the adjusted fIBI calculation resulted in a decrease in the score of roughly the same magnitude, indicating that the adjusted calculation was not too sensitive to the number of fish in the individual samples in these data sets.

As an additional line of evidence for the status of the fish community, statistical analysis of the fish samples from each reach using the Shannon-Weiner and Simpson's diversity indices was conducted. The diversity index values for each reach adjacent to the Site were not statistically different from the similar index value for the upstream reference reach. This additional analysis also supports the conclusion that the ecological condition of the fish community in the LVR along the Site appears to be similar to the "background" conditions measured at the same-stream reference reach, which is un-impacted by the Site.

Macroinvertebrate scores for the sample reaches adjacent to the Site were variable with reaches along the middle and southern portion of the slag pile having generally lower mIBI scores and some lower Shannon-Weiner and Simpson's diversity index scores. However, the lower mIBI scores still reflect a generally healthy and balanced macroinvertebrate community at least comparable in biotic integrity to that expected for Illinois streams (i.e., IEPA Integrity Class 2). Additionally, CAR003 (both east and west halves), which is located along the northern edge of the slag pile and immediately downstream of the CSO and ASO, had mIBI scores exceeding those for the reference reach and diversity indices that were statistically indistinguishable from the reference reach. As noted previously, there is some uncertainty associated with the comparisons of Site mIBI data to IEPA best metric values; however, when considering the available species diversity data in total for the reaches adjacent to the Site, evidence indicates the greater probability that the macroinvertebrate community of the LVR adjacent to the Site is not significantly different from "background" species diversity measured at the same-stream reference reach. The results for the additional FRSS analysis of the macroinvertebrate community in the LVR are supportive of a similar conclusion.

While formal decisions regarding designated use support of Illinois surface waters are the purview of IEPA and beyond the scope of this assessment, the combined fIBI and mIBI scores (or MBI scores, if the mIBI is deemed unavailable) calculated in this study for the sampled reaches of the LVR (including those adjacent to the Site) are consistent with a preliminary determination that those LVR reaches show “No Impairment” and are “Fully Supporting” of aquatic life use and are indicative of good resource quality. The results for the additional FRSS analysis of the macroinvertebrate community in the LVR are supportive of a similar conclusion.

The results of all these analyses undertaken as part of this bioassessment contribute information and lines of evidence for consideration in the context of a full weight-of-evidence evaluation, which comprises the scientific burden of proof for this project in accordance with USEPA ecological risk assessment guidance (USEPA, 1997). The full weight-of-evidence evaluation considers the bioassessment analyses presented in this report together with other analyses contained in Section 4.1 (OU1 BERA) of Appendix RA (Risk Assessment) of the RI Report for the Site. Depending on the results of the BERA and the HHRA, potential remedial alternatives to address contaminants at the Site that may impact the LVR will be evaluated as part of the Site feasibility study.

5.0 REFERENCES

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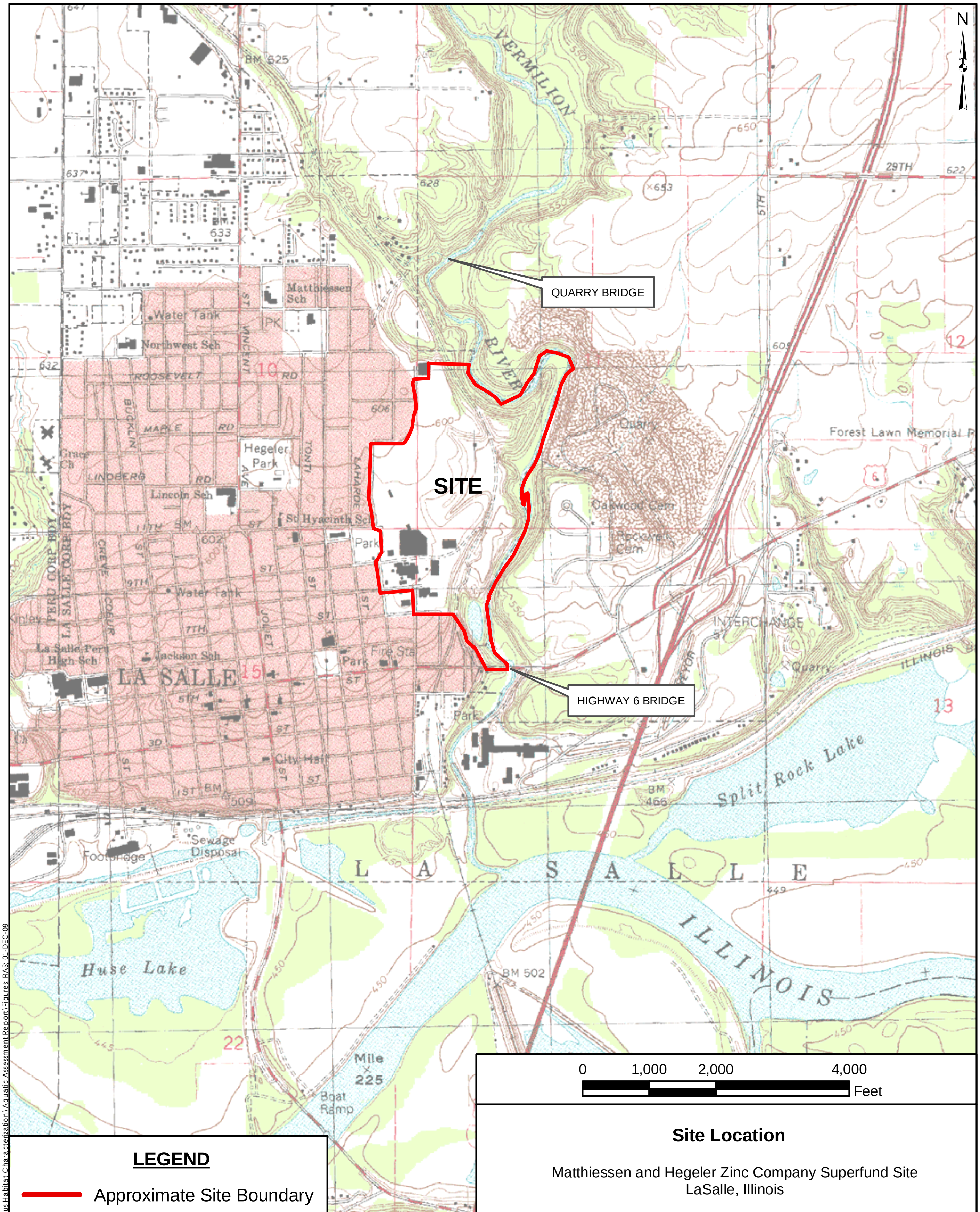
FIGURES



LEGEND

Approximate Site Boundary

Site Location

Matthiessen and Hegeler Zinc Company Superfund Site
LaSalle, Illinois

Note:

Basemap Source:
USGS 7.5 min Series, LaSalle Quadrangle (1994)

Geosyntec consultants

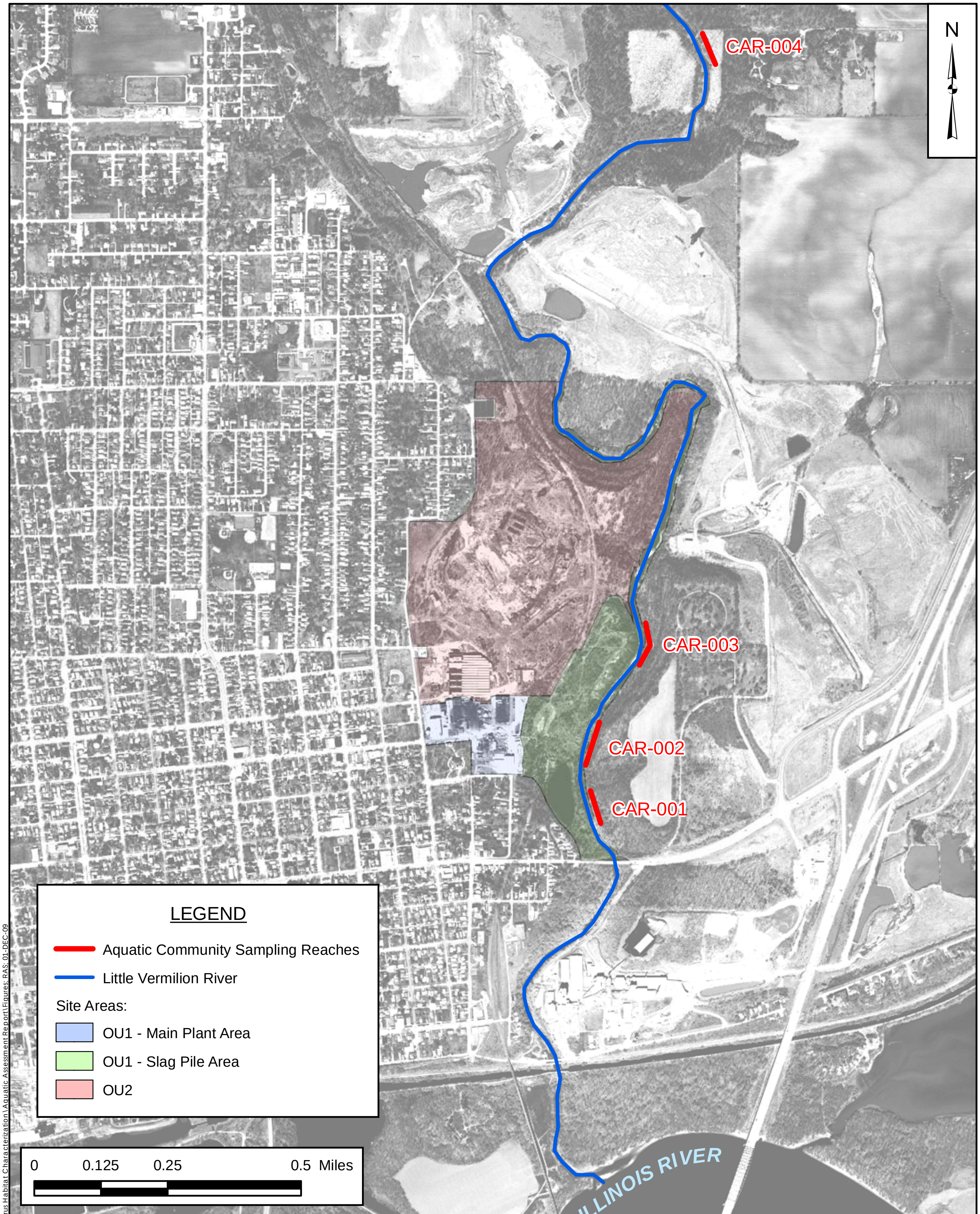
CARUS

Jacksonville, FL

01-DEC-2009

Figure **1-1**

P:\Kennesaw\Projects\FR1347_Carus Habitat Characterization\Aquatic Assessment Report\Figures; RAS; 01-DEC-09



Geosyntec consultants	CARUS	**Aquatic Community Sampling Reaches** Matthiessen and Hegeler Zinc Company Site, OU1 LaSalle, Illinois	Figure **2-1**
Jacksonville, FL	01-DEC-2009		

P:\Kennesaw\Projects\FR1347 Carus Habitat Characterization\Aquatic Assessment Report\Figures; RAS; 01-DEC-09

Photograph of slag substrate along Little Vermilion River near CAR002.

Looking north along Little Vermilion River and slag pile slope near CAR003.

Representative Photographs Little Vermilion River Biological Assessment LaSalle County, Illinois		
Geosyntec consultants Atlanta, Georgia	Project No. FR1347T January 2010	**Figure** **2-2**

Representative photograph of electrofishing team, note block nets in background.

Representative photograph of fish seining.

Representative Photographs Little Vermilion River Biological Assessment LaSalle County, Illinois		
Geosyntec consultants Atlanta, Georgia	Project No. FR1347T January 2010	**Figure** **2-3**

Representative photograph of fish identification and processing.

Representative photograph of electrofishing effort near woody debris habitat.

Representative Photographs Little Vermilion River Biological Assessment LaSalle County, Illinois		
Geosyntec consultants Atlanta, Georgia	Project No. FR1347T January 2010	**Figure** **2-4**

Team biologists using hand grubbing and viewing buckets for mussel survey.

Snorkeling for mussels along Little Vermilion River at CAR001.

Representative Photographs Little Vermilion River Biological Assessment LaSalle County, Illinois		
Geosyntec consultants Atlanta, Georgia	Project No. FR1347T January 2010	**Figure** **2-5**

Representative photograph of CAR004.

Looking upstream along reach CAR004.

Representative Photographs

Little Vermilion River Biological Assessment

LaSalle County, Illinois

Geosyntec consultants Atlanta, Georgia	Project No. FR1347T January 2010	**Figure** **2-6**

TABLES

Table 3-1. Summary of Fisheries Data for Little Vermilion River Aquatic Assessment - August 11-13, 2009

Species Common Name	Species Scientific Name	Sample Locations - No. of Fish Collected CAR001 Slag	CAR002 Slag	CAR003 Slag/CSO	CAR004 Reference
Central stoneroller	*Campostoma anomalum*	31	1	1	7
Grass carp*	*Ctenopharyngodon idella*	1			
Spotfin shiner	*Cyprinella spiloptera*	10			1
Common carp	*Cyprinus carpio*		1	1	
Striped shiner	*Luxilus chrysocephalus*				2
Common shiner	*Luxilus cornutus*			2	8
Redfin shiner	*Lythrurus umbratilis*		1	6	
Hornyhead chub	*Nocomis biguttatus*	5	1	2	4
Northern hog sucker	*Hypentelium nigricans*	29	5	16	43
Creek chub	*Semotilus atromaculatus*		1		4
black redhorse	*Moxostoma duquesnei*	5	2	7	2
Golden redhorse	*Moxostoma erythrurum*				3
Shorthead redhorse	*Moxostoma macrolepidotum*	2	4	2	
Channel catfish	*Ictaluris punctatus*	1			
Green sunfish	*Lepomis cyanellus*	3	5	2	1
Bluegill	*Lepomis macrochirus*	4	17	11	3
Longear sunfish*	*Lepomis megalotis*		2	1	
Smallmouth bass	*Micropterus dolomieu*	3	1	2	6
Largemouth bass	*Micropterus salmoides*	1		1	1
Rainbow darter*	*Etheostoma caeruleum*				9
Fantail darter	*Etheostoma flabellare*				1
Johnny darter	*Etheostoma nigrum*				18
Banded darter	*Etheostoma zonale*	2	4		
Logperch	*Percina caprodes*	9	7	5	
Sauger*	*Sander canadensis*			1	
bluntnose minnow	*Pimephales notatus*	1	1		52
Sand shiner	*Notropis ludibundus*				1
White sucker	*Catostomus commersoni*				6
Freshwater drum*	*Aplodinotus grunniens*			1	
Note:	**No. of species/taxa**	**15**	**15**	**16**	**19**
*Previously uncollected	**No. of individuals**	**107**	**53**	**61**	**172**
in watershed.	**Electrofish Effort (minutes)**	**36**	**36**	**36**	**36**
	Catch per unit effort	**3.0**	**1.5**	**1.7**	**4.8**

Prepared by: JAW
Date: 12/1/2010
Checked/Revised by: TEC
Date: 11/3/2010

Table 3-2. CAR001 Index of Biotic Integrity Worksheet-Little Vermilion River Aquatic Assessment - August 11-13, 2009

Known Species in LVR Watershed	Scientific Name	CAR001 Slag	NFSH	NBIVN	SBI	GEN	LITOT	TOL
Central stoneroller	*Campostoma anomalum*	31	Yes	No	--	--	Yes	--
Grass carp*	*Ctenopharyngodon idella*	1	No	No	--	Yes	--	--
Hornyhead chub	*Nocomis biguttatus*	5	Yes	No	--	--	Yes	intolerant
Spotfin shiner	*Cyprinella spiloptera*	10	Yes	No	--	Yes	--	--
Bluntnose minnow	*Pimephales notatus*	1	Yes	No	--	Yes	--	tolerant
Northern hog sucker	*Hypentelium nigricans*	29	Yes	Yes	Yes	--	Yes	intolerant
Black redhorse	*Moxostoma duquesnei*	5	Yes	Yes	Yes	--	Yes	intolerant
Shorthead redhorse	*Moxostoma macrolepidotum*	2	Yes	Yes	Yes	--	Yes	--
Channel catfish	*Ictalurus punctatus*	1	Yes	No	--	Yes	--	--
Green sunfish	*Lepomis cyanellus*	3	Yes	No	--	Yes	--	tolerant
Bluegill	*Lepomis macrochirus*	4	Yes	No	--	Yes	--	--
Smallmouth bass	*Micropterus dolomieui*	3	Yes	No	--	--	Yes	intolerant
Largemouth bass	*Micropterus salmoides*	1	Yes	No	--	--	--	--
Banded darter	*Etheostoma zonale*	2	Yes	Yes	Yes	--	--	intolerant
Logperch	*Percina caprodes*	9	Yes	Yes	Yes	--	Yes	--
	Count	**15**	**14**					

*Previously uncollected in the watershed

Number of species	15
Number of individuals	107
No. of Native Fish (NFSH)	14
No. of Native Suckers (NSUC - Catostomidae)	3
No. of Native Sunfish (NSUN - Centrarchidae)	4
No. of Intolerant Species	5
No. of Native Minnows (NMIN -Cyprinidae)	4
No. of Native Benthic Invertivores (NBIVN)	5
Proportion of Specialized Benthic Invertivores (SBI)	0.44
Proportion of Generalist Feeders (GEN)	0.19
Proportion of Mineral Substrate Spawners (LITOT)	0.79
Proportion of Tolerant Species (PRTOL)	0.04

Prepared by:	JAW
Date:	12/1/2010
Checked by:	TEC
Date:	11/3/2010

Table 3-3. CAR002 Index of Biotic Integrity Worksheet - Little Vermilion River Aquatic Assessment - August 11-13, 2009

Known Species in LVR Watershed	Scientific Name	CAR002 Slag	NFSH	NBIVN	SBI	GEN	LITOT	TOL
Central stoneroller	*Campostoma anomalum*	1	Yes	No	--	--	Yes	--
Common carp	*Cyprinus carpio*	1	No	No	--	Yes	--	tolerant
Redfin shiner	*Lythrurus umbratilis*	1	Yes	No	--	Yes	Yes	--
Hornyhead chub	*Nocomis biguttatus*	1	Yes	No	--	--	Yes	intolerant
Bluntnose minnow	*Pimephales notatus*	1	Yes	No	--	Yes	--	tolerant
Creek chub	*Semotilus atromaculatus*	1	Yes	No	--	Yes	--	tolerant
Northern hog sucker	*Hypentelium nigricans*	5	Yes	Yes	Yes	--	Yes	intolerant
Black redhorse	*Moxostoma duquesnei*	2	Yes	Yes	Yes	--	Yes	intolerant
Shorthead redhorse	*Moxostoma macrolepidotum*	4	Yes	Yes	Yes	--	Yes	--
Green sunfish	*Lepomis cyanellus*	5	Yes	No	--	Yes	--	tolerant
Bluegill	*Lepomis macrochirus*	17	Yes	No	--	Yes	--	--
Longear sunfish*	*Lepomis megalotis*	2	Yes	No	--	--	--	--
Smallmouth bass	*Micropterus dolomieui*	1	Yes	No	--	--	Yes	intolerant
Banded darter	*Etheostoma zonale*	4	Yes	Yes	Yes	--	--	intolerant
Logperch	*Percina caprodes*	7	Yes	Yes	Yes	--	Yes	--
	Count	**15**	**14**					

*Previously uncollected in the watershed

Number of species	15
Number of individuals	53
No. of Native Fish (NFSH)	14
No. of Native Suckers (NSUC - Catostomidae)	3
No. of Native Sunfish (NSUN - Centrarchidae)	4
No. of Intolerant Species	5
No. of Native Minnows (NMIN -Cyprinidae)	5
No. of Native Benthic Invertivores (NBIVN)	5
Proportion of Specialized Benthic Invertivores (SBI)	0.42
Proportion of Generalist Feeders (GEN)	0.49
Proportion of Mineral Substrate Spawners (LITOT)	0.42
Proportion of Tolerant Species (PRTOL)	0.15

Prepared by:	JAW
Date:	12/1/2010
Checked by:	TEC
Date:	11/3/2010

Table 3-4. CAR003 Index of Biotic Integrity Worksheet, Little Vermilion River - August 11-13, 2009

Known Species in LVR Watershed	Scientific Name	CAR003 Slag/CSO	NFSH	NBIVN	SBI	GEN	LITOT	TOL
Central stoneroller	*Campostoma anomalum*	1	Yes	No	--	--	Yes	--
Common carp	*Cyprinus carpio*	1	No	No	--	Yes	--	tolerant
Common shiner	*Luxilus cornutus*	2	Yes	No	--	Yes	Yes	--
Redfin shiner	*Lythrurus umbratilis*	6	Yes	No	--	Yes	Yes	--
Hornyhead chub	*Nocomis biguttatus*	2	Yes	No	--	--	Yes	intolerant
Northern hog sucker	*Hypentelium nigricans*	16	Yes	Yes	Yes	--	Yes	intolerant
Black redhorse	*Moxostoma duquesnei*	7	Yes	Yes	Yes	--	Yes	intolerant
Shorthead redhorse	*Moxostoma macrolepidotum*	2	Yes	Yes	Yes	--	Yes	--
Green sunfish	*Lepomis cyanellus*	2	Yes	No	--	Yes	--	tolerant
Bluegill	*Lepomis macrochirus*	11	Yes	No	--	Yes	--	--
Longear sunfish*	*Lepomis megalotis*	1	Yes	No	--	--	--	--
Smallmouth bass	*Micropterus dolomieui*	2	Yes	No	--	--	Yes	intolerant
Largemouth bass	*Micropterus salmoides*	1	Yes	No	--	--	--	--
Logperch	*Percina caprodes*	5	Yes	Yes	Yes	--	Yes	--
Sauger*	*Sander canadensis*	1	Yes	No	--	--	Yes	--
Freshwater drum*	*Aplodinotus grunniens*	1	Yes	No	--	--	--	--
	Count	**16**	**15**					

*Previously uncollected in the watershed

Number of species	16
Number of individuals	61
No. of Native Fish (NFSH)	15
No. of Native Suckers (NSUC - Catostomidae)	3
No. of Native Sunfish (NSUN - Centrarchidae)	5
No. of Intolerant Species	4
No. of Native Minnows (NMIN -Cyprinidae)	4
No. of Native Benthic Invertivores (NBIVN)	4
Proportion of Specialized Benthic Invertivores (SBI)	0.49
Proportion of Generalist Feeders (GEN)	0.36
Proportion of Mineral Substrate Spawners (LITOT)	0.72
Proportion of Tolerant Species (PRTOL)	0.05

Prepared by: JAW
Date: 12/1/2010
Checked by: TEC
Date: 11/3/2010

Table 3-5. CAR004 Index of Biotic Integrity Worksheet, Little Vermilion River Aquatic Assessment-August 11-13, 2009

Known Species in LVR Watershed	Scientific Name	CAR004 Reference	NFSH	NBIVN	SBI	GEN	LITOT	TOL
Central stoneroller	*Campostoma anomalum*	7	Yes	No	--	--	Yes	--
Spotfin shiner*	*Cyprinella spiloptera*	1	Yes	No	--	Yes	--	--
Striped shiner	*Luxilus chrysocephalus*	2	Yes	No	--	Yes	Yes	--
Sand shiner	*Notropis ludibundus*	1	Yes	No	--	Yes	--	--
Common shiner	*Luxilus cornutus*	8	Yes	No	--	Yes	Yes	--
Hornyhead chub	*Nocomis biguttatus*	4	Yes	No	--	--	Yes	intolerant
Bluntnose minnow	*Pimephales notatus*	52	Yes	No	--	Yes	--	tolerant
Creek chub	*Semotilus atromaculatus*	4	Yes	No	--	Yes	--	tolerant
Northern hog sucker	*Hypentelium nigricans*	43	Yes	Yes	Yes	--	Yes	intolerant
White Sucker	*Catostomus commersoni*	6	Yes	No	--	Yes	--	tolerant
Black redhorse	*Moxostoma duquesnei*	2	Yes	Yes	Yes	--	Yes	intolerant
Golden redhorse	*Moxostoma erythrurum*	3	Yes	Yes	Yes	--	Yes	--
Green sunfish	*Lepomis cyanellus*	1	Yes	No	--	Yes	--	tolerant
Bluegill	*Lepomis macrochirus*	3	Yes	No	--	Yes	--	--
Smallmouth bass	*Micropterus dolomieui*	6	Yes	No	--	--	Yes	intolerant
Largemouth bass	*Micropterus salmoides*	1	Yes	No	--	--	--	--
Rainbow darter*	*Etheostoma caeruleum*	9	Yes	Yes	Yes	--	Yes	intolerant
Fantail darter	*Etheostoma flabellare*	1	Yes	Yes	Yes	--	--	--
Johnny darter	*Etheostoma nigrum*	18	Yes	Yes	Yes	--	--	--
	Count	**19**	**19**					

*Previously uncollected in the watershed

Number of species	19
Number of individuals	172
No. of Native Fish (NFSH)	19
No. of Native Suckers (NSUC - Catostomidae)	4
No. of Native Sunfish (NSUN - Centrarchidae)	4
No. of Intolerant Species	5
No. of Native Minnows (NMIN -Cyprinidae)	8
No. of Native Benthic Invertivores (NBIVN)	6
Proportion of Specialized Benthic Invertivores (SBI)	0.44
Proportion of Generalist Feeders (GEN)	0.45
Proportion of Mineral Substrate Spawners (LITOT)	0.49
Proportion of Tolerant Species (PRTOL)	0.37

Prepared by: JAW
Date: 12/1/2010
Checked by: TEC
Date: 11/3/2010

Table 3-6. Fish Community Biotic Integrity Score and Integrity Class for Station CAR001, Little Vermilion River - August 13, 2009.

Illinois EPA - Index of Biotic Integrity Index Worksheet				**Score Category**								
	Metric Description	**Code**	**CAR001 Result**	6	5	4	3	2	1	0	**Metric Score**
	Species Richness Metrics										
1.	Number of native fish species	NFSH	14	> 30	26 - 30	21-25	16-20	11-15	6-10	≤5	**2**
2.	Number of native sucker species (Catostomidae)	NSUC	3	> 6	6	5	3-4	2	1	0	**3**
3.	Number of native sunfish species (Centrarchidae)	NSUN	4	> 5	5	4	3	2	1	0	**4**
4.	Number of native intolerant species	INTOL	5	> 5	5	4	3	2	1	0	**5**
5.	Number of native minnow species (Cyprinidae)	NMIN	4	>10	9-10	7-8	5-6	3-4	1-2	0	**2**
6.	Number of native benthic invertivores (species)	NBIVN	5	>10	9-10	7-8	5-6	3-4	1-2	0	**3**
	Trophic- or Reproductive-structure Metrics										
7.	Proportion of individuals of species that are benthic invertivores	SBI	0.44	> 0.179	0.145-0.179	0.109-0.144	0.073-0.108	0.036-0.072	0.001-0.035	0	**6**
8.	Proportion of individuals of species that are generalist feeders	GEN	0.19	< 0.51	0.51-0.61	0.62-0.71	0.72-0.805	0.81-0.90	0.91-0.99	1	**6**
9.	Proportion of individuals of species that are obligate coarse-mineral substrate spawners and not "tolerant" (excludes creek chub & white sucker)	LITOT	0.79	> 0.44	0.36-0.44	0.27-0.35	0.17-0.26	0.10-0.16	0.01-0.09	0	**6**
	Pollution Tolerance Metric										
10.	Proportion of tolerant species	PRTOL	0.04	< 0.16	0.17-0.33	0.34 - 0.50	0.51 - 0.66	0.67-0.83	0.84- 0.99	1	**6**
Fish Index of Biotic Integrity (fIBI)											**43**
IEPA Integrity Class											**Class 3**

Fish Index of Biotic Integrity [fIBI ≥ 41 Consistent with Designation of Fully Supporting Aquatic Life Use]	**Points**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)	56 - 60
Class 2 - Biotic integrity is similar than expected in Illinois streams	46 - 55
Class 3 - Biotic integrity is lower than expected in Illinois streams	31 - 45
Class 4 - Biotic integrity is much lower than expected in Illinois stream	16 - 30
Class 5 - Biotic integrity is much lower than expected in Illinois stream	0 - 15

Prepared by: JAW
Date: 9/4/2009
Checked/Revised by: TEC
Date: 11/3/2010

CAR001: MSW - 45.0 feet; Slope: 0.72%

Table 3-7. Fish Community Biotic Integrity Score and Integrity Class for Station CAR002, Little Vermilion River - August 11-13, 2009.

Illinois EPA - Index of Biotic Integrity Index Worksheet			**Score Category**								
	Metric Description	**Code**	**CAR002 Result**	6	5	4	3	2	1	0	**Metric Score**
	Species Richness Metrics										
1.	Number of native fish species	NFSH	14	> 30	26 - 30	21-25	16-20	11-15	6-10	≤5	**2**
2.	Number of native sucker species (Catostomidae)	NSUC	3	> 6	6	5	3-4	2	1	0	**3**
3.	Number of native sunfish species (Centrarchidae)	NSUN	4	> 5	5	4	3	2	1	0	**4**
4.	Number of native intolerant species	INTOL	5	> 5	5	4	3	2	1	0	**5**
5.	Number of native minnow species (Cyprinidae)	NMIN	5	>10	9-10	7-8	5-6	3-4	1-2	0	**3**
6.	Number of native benthic invertivores (species)	NBIVN	5	>10	9-10	7-8	5-6	3-4	1-2	0	**3**
	Trophic- or Reproductive-structure Metrics										
7.	Proportion of individuals of species that are benthic invertivores	SBI	0.42	> 0.179	0.145-0.179	0.109-0.144	0.073-0.108	0.036-0.072	0.001-0.035	0	**6**
8.	Proportion of individuals of species that are generalist feeders	GEN	0.49	< 0.51	0.51-0.61	0.62-0.71	0.72-0.805	0.81-0.90	0.91-0.99	1	**6**
9.	Proportion of individuals of species that are obligate coarse-mineral substrate spawners and not "tolerant" (excludes creek chub & white sucker)	LITOT	0.42	> 0.44	0.36-0.44	0.27-0.35	0.17-0.26	0.10-0.16	0.01-0.09	0	**5**
	Pollution Tolerance Metric										
10.	Proportion of tolerant species	PRTOL	0.15	< 0.16	0.17-0.33	0.34 - 0.50	0.51 - 0.66	0.67-0.83	0.84- 0.99	1	**6**
Fish Index of Biotic Integrity (fIBI)											**43**
IEPA Integrity Class											**Class 3**

Fish Index of Biotic Integrity [fIBI ≥ 41 Consistent with Designation of Fully Supporting Aquatic Life Use]	**Points**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)	56 - 60
Class 2 - Biotic integrity is similar than expected in Illinois streams	46 - 55
Class 3 - Biotic integrity is lower than expected in Illinois streams	31 - 45
Class 4 - Biotic integrity is much lower than expected in Illinois stream	16 - 30
Class 5 - Biotic integrity is much lower than expected in Illinois stream	0 - 15

CAR002: MSW - 45.0 feet; Slope: 2.87%

Prepared by: JAW
Date: 9/4/2009
Checked/Revised by: TEC
Date: 11/3/2010

Table 3-8. Fish Community Biotic Integrity Score and Integrity Class for Station CAR003, Little Vermilion River - August 11-13, 2009.

Illinois EPA - Index of Biotic Integrity Index Worksheet				Score Category							
	Metric Description	Code	CAR003 Result	6	5	4	3	2	1	0	Metric Score
	Species Richness Metrics										
1.	Number of native fish species	NFSH	15	> 30	26 - 30	21-25	16-20	11-15	6-10	≤5	**2**
2.	Number of native sucker species (Catostomidae)	NSUC	3	> 6	6	5	3-4	2	1	0	**3**
3.	Number of native sunfish species (Centrarchidae)	NSUN	5	> 5	5	4	3	2	1	0	**5**
4.	Number of native intolerant species	INTOL	4	> 5	5	4	3	2	1	0	**4**
5.	Number of native minnow species (Cyprinidae)	NMIN	4	>10	9-10	7-8	5-6	3-4	1-2	0	**2**
6.	Number of native benthic invertivores (species)	NBIVN	4	>10	9-10	7-8	5-6	3-4	1-2	0	**2**
	Trophic- or Reproductive-structure Metrics										
7.	Proportion of individuals of species that are benthic invertivores	SBI	0.49	> 0.179	0.145-0.179	0.109-0.144	0.073-0.108	0.036-0.072	0.001-0.035	0	**6**
8.	Proportion of individuals of species that are generalist feeders	GEN	0.36	< 0.51	0.51-0.61	0.62-0.71	0.72-0.805	0.81-0.90	0.91-0.99	1	**6**
9.	Proportion of individuals of species that are obligate coarse-mineral substrate spawners and not "tolerant" (excludes creek chub & white sucker)	LITOT	0.72	> 0.44	0.36-0.44	0.27-0.35	0.17-0.26	0.10-0.16	0.01-0.09	0	**6**
	Pollution Tolerance Metric										
10.	Proportion of tolerant species	PRTOL	0.05	< 0.16	0.17-0.33	0.34 - 0.50	0.51 - 0.66	0.67-0.83	0.84- 0.99	1	**6**
Fish Index of Biotic Integrity (fIBI)											**42**
IEPA Integrity Class											**Class 3**

Fish Index of Biotic Integrity [fIBI ≥ 41 Consistent with Designation of Fully Supporting Aquatic Life Use]	**Points**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)	56 - 60
Class 2 - Biotic integrity is similar than expected in Illinois streams	46 - 55
Class 3 - Biotic integrity is lower than expected in Illinois streams	31 - 45
Class 4 - Biotic integrity is much lower than expected in Illinois stream	16 - 30
Class 5 - Biotic integrity is much lower than expected in Illinois stream	0 - 15

CAR003: MSW - 40.0 feet; Slope: 0.35%

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Date: 9/4/2009
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Date: 11/3/2010

Table 3-9. Fish Community Biotic Integrity Score and Integrity Class for Station CAR004, Little Vermilion River, August 11-13, 2009.

Illinois EPA - Index of Biotic Integrity Index Worksheet				Score Category							
	Metric Description	Code	CAR004 Result	6	5	4	3	2	1	0	Metric Score
	Species Richness Metrics										
1.	Number of native fish species	NFSH	19	> 30	26 - 30	21-25	16-20	11-15	6-10	≤5	**3**
2.	Number of native sucker species (Catostomidae)	NSUC	4	> 6	6	5	3-4	2	1	0	**3**
3.	Number of native sunfish species (Centrarchidae)	NSUN	4	> 5	5	4	3	2	1	0	**4**
4.	Number of native intolerant species	INTOL	5	> 5	5	4	3	2	1	0	**5**
5.	Number of native minnow species (Cyprinidae)	NMIN	8	>10	9-10	7-8	5-6	3-4	1-2	0	**4**
6.	Number of native benthic invertivores (species)	NBIVN	6	>10	9-10	7-8	5-6	3-4	1-2	0	**3**
	Trophic- or Reproductive-structure Metrics										
7.	Proportion of individuals of species that are benthic invertivores	SBI	0.44	> 0.179	0.145-0.179	0.109-0.144	0.073-0.108	0.036-0.072	0.001-0.035	0	**6**
8.	Proportion of individuals of species that are generalist feeders	GEN	0.45	< 0.51	0.51-0.61	0.62-0.71	0.72-0.805	0.81-0.90	0.91-0.99	1	**6**
9.	Proportion of individuals of species that are obligate coarse-mineral substrate spawners and not "tolerant" (excludes creek chub & white sucker)	LITOT	0.49	> 0.44	0.36-0.44	0.27-0.35	0.17-0.26	0.10-0.16	0.01-0.09	0	**6**
	Pollution Tolerance Metric										
10.	Proportion of tolerant species	PRTOL	0.37	< 0.16	0.17-0.33	0.34 - 0.50	0.51 - 0.66	0.67-0.83	0.84- 0.99	1	**4**
Fish Index of Biotic Integrity (fIBI)											**44**
IEPA Integrity Class											**Class 3**

Fish Index of Biotic Integrity [fIBI ≥ 41 Consistent with Designation of Fully Supporting Aquatic Life Use]	**Points**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)	56 - 60
Class 2 - Biotic integrity is similar than expected in Illinois streams	46 - 55
Class 3 - Biotic integrity is lower than expected in Illinois streams	31 - 45
Class 4 - Biotic integrity is much lower than expected in Illinois stream	16 - 30
Class 5 - Biotic integrity is much lower than expected in Illinois stream	0 - 15

CAR004: MSW - 46.0 feet; Slope: 0.18%

Prepared by: JAW
Date: 9/4/2009
Checked/Revised by: TEC
Date: 11/3/2010

Table 3-10. Summary of Fish Community Biotic Integrity Scores and Integrity Classes for Sampling Stations, Little Vermilion River, August 11-13, 2009.

Illinois EPA - Index of Biotic Integrity Index Worksheet		Metric Result & Score by Station							
		CAR004		CAR003		CAR002		CAR001	
Metric Description		Result	Score	Result	Score	Result	Score	Result	Score
	Species Richness Metrics								
1.	Number of native fish species	19	**3**	15	**2**	14	**2**	14	**2**
2.	Number of native sucker species (Catostomidae)	4	**3**	3	**3**	3	**3**	3	**3**
3.	Number of native sunfish species (Centrarchidae)	4	**4**	5	**5**	4	**4**	4	**4**
4.	Number of native intolerant species	5	**5**	4	**4**	5	**5**	5	**5**
5.	Number of native minnow species (Cyprinidae)	8	**4**	4	**2**	5	**3**	4	**2**
6.	Number of native benthic invertivores (species)	6	**3**	4	**2**	5	**3**	5	**3**
	Trophic- or Reproductive-structure Metrics								
7.	Proportion of individuals of species that are specialist benthic invertivores	0.44	**6**	0.49	6	0.42	**6**	0.44	**6**
8.	Proportion of individuals of species that are generalist feeders	0.45	**6**	0.36	6	0.49	**6**	0.19	**6**
9.	Proportion of individuals of species that are obligate coarse-mineral substrate spawners and not "tolerant" (excludes creek chub & white sucker)	0.49	**6**	0.72	6	0.42	**5**	0.79	**6**
	Pollution Tolerance Metric								
10.	Proportion of tolerant species	0.37	**4**	0.05	6	0.15	6	0.04	6
Fish Index of Biotic Integrity (fIBI) Score			**44**		**42**		**43**		**43**
IEPA Integrity Class			**Class 3**		**Class 3**		**Class 3**		**Class 3**

Fish Index of Biotic Integrity [fIBI ≥41 Consistent with Designation of Fully Supporting Aquatic Life Use]	**Points**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)	56 - 60
Class 2 - Biotic integrity is similar than expected in Illinois streams	46 - 55
Class 3 - Biotic integrity is lower than expected in Illinois streams	31 - 45
Class 4 - Biotic integrity is much lower than expected in Illinois stream	16 - 30
Class 5 - Biotic integrity is much lower than expected in Illinois stream	0 - 15

Prepared by: JAW
Date: 9/4/2009
Checked by: TEC
Date: 11/3/2010

Table 3-11. Station CAR001East mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Caecidotea sp.	10	6	CG	60
Ephemeroptera				
Baetis sp.	3	4	CG	12
Odonata				
Boyeria sp.	1	3	PR	3
Calopteryx sp.	5	4	PR	20
Megaloptera				
Corydalus sp.	1	3	PR	3
Trichoptera				
Ceratopsyche sp.	52	4	CF	208
Cheumatopsyche sp.	48	6	CF	288
Hydropsyche sp.	51	5	CF	255
Hydroptila sp.	7	2	SC	14
Oecetis sp.	3	5	PR	15
Neureclipsis sp.	3	3	CF	9
Coleoptera (less semi-				
Dubiraphia sp.	23	5	CG	115
Macronychus sp.	10	2	---	20
Stenelmis sp.	10	7	SC	70
Diptera				
Brillia sp.	3	6	SH	18
Cardiocladius sp.	73	6	PR	438
Chironomus sp.	1	11	CG	11
Conchapelopia sp.	2	6	PR	12
Cricotopus sp.	13	8	SH	104
Diamesa sp.	1	4	CG	4
Microtendipes sp.	1	6	CF	6
Orthocladius sp.	1	4	CG	4
Parakiefferiella sp.	1	5	---	5
Polypedilum sp.	5	6	SH	30
Stenochironomus sp.	7	3	SH	21
Tribelos sp.	2	5	CG	10
Hemerodromia sp.	5	6	PR	30
Simuliidae	3	6	CF	18
Simulium sp.	11	6	CF	66
Tipula sp.	1	4	SH	4
Total # Individuals	**357**		MBI =	**5.2**
Total Taxa (IEPA)	**30**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**30**
Number of Coleoptera Taxa	**3**
Number of Ephemeroptera Taxa	**1**
Number of Intolerant Taxa (TV ≤ 3.0)	**6**
Macroinvertebrate Biotic Index (MBI)	**5.2**
Percent Individuals as Scrapers (FFG=SC)	**4.8%**
Percent Individuals as EPT	**46.8%**

Table 3-12. Station CAR001West mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Corbicula	1	4	CF	4
Fossaria sp.	1	7	SC	7
Physella sp.	2	9	SC	18
Oligochaeta - Grouped	1	10	CG	10
Caecidotea sp.	2	6	CG	12
Odonata				
Calopterygidae	1	3.5	PR	3.5
Hetaerina sp.	2	3	PR	6
Argia sp.	1	5	PR	5
Ischnura sp.	1	6	PR	6
Megaloptera				
Corydalus sp.	2	3	PR	6
Sialis sp.	1	4	PR	4
Trichoptera				
Hydropsychidae	10	5.5	CF	55
Ceratopsyche sp.	21	4	CF	84
Cheumatopsyche sp.	50	6	CF	300
Hydropsyche sp.	38	5	CF	190
Hydroptila sp.	10	2	SC	20
Nectopsyche sp.	1	3	SH	3
Oecetis sp.	1	5	PR	5
Neureclipsis sp.	8	3	CF	24
Coleoptera (less semi-aquatics)				
Ancyronyx sp.	1	2	CG	2
Dubiraphia sp.	18	5	CG	90
Macronychus sp.	1	2	---	2
Stenelmis sp.	6	7	SC	42
Diptera				
Ablabesmyia sp.	2	6	CG	12
Cardiocladius sp.	41	6	PR	246
Conchapelopia sp.	5	6	PR	30
Cricotopus sp.	17	8	SH	136
Dicrotendipes sp.	1	6	CG	6
Microtendipes sp.	2	6	CF	12
Nanocladius sp.	1	3	CG	3
Nilothauma sp.	7	3	---	21
Paracladopelma sp.	4	4	CG	16
Phaenopsectra sp.	1	4	SC	4
Polypedilum sp.	13	6	SH	78
Stenochironomus sp.	1	3	SH	3
Tribelos sp.	6	5	CG	30
Tvetenia sp.	1	5	---	5
Zavrelimyia sp.	1	8	PR	8
Hemerodromia sp.	2	6	PR	12
Ephydridae	1	8	CG	8
Simulium sp.	17	6	CF	102
Tipula sp.	1	4	SH	4
Total # Individuals	**304**		**MBI =**	**5.4**
Total Taxa (IEPA)	**42**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**42**
Number of Coleoptera Taxa	**4**
Number of Ephemeroptera Taxa	**0**
Number of Intolerant Taxa (TV ≤ 3.0)	**10**
Macroinvertebrate Biotic Index (MBI)	**5.4**
Percent Individuals as Scrapers (FFG=SC)	**6.6%**
Percent Individuals as EPT	**45.7%**

Table 3-13. Station CAR002East mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Oligochaeta - Grouped	1	10	CG	10
Caecidotea sp.	7	6	CG	42
Ephemeroptera				
Baetis sp.	5	4	CG	20
Tricorythodes sp.	1	5	CG	5
Odonata				
Boyeria sp.	1	3	PR	3
Calopterygidae	24	3.5	PR	84
Calopteryx sp.	4	4	PR	16
Hetaerina sp.	1	3	PR	3
Argia sp.	2	5	PR	10
Ischnura sp.	1	6	PR	6
Gomphidae	1	4.5	PR	4.5
Macromia sp.	1	3	PR	3
Trichoptera				
Ceratopsyche sp.	15	4	CF	60
Cheumatopsyche sp.	8	6	CF	48
Hydropsyche sp.	15	5	CF	75
Hydroptila sp.	7	2	SC	14
Nectopsyche sp.	3	3	SH	9
Oecetis sp.	1	5	PR	5
Neureclipsis sp.	2	3	CF	6
Coleoptera (less semi-aquatics)				
Dubiraphia sp.	68	5	CG	340
Macronychus sp.	2	2	---	4
Stenelmis sp.	18	7	SC	126
Diptera				
Ablabesmyia sp.	5	6	CG	30
Brillia sp.	1	6	SH	6
Cardiocladius sp.	23	6	PR	138
Chironomus sp.	3	11	CG	33
Cladotanytarsus sp.	3	7	CG	21
Conchapelopia sp.	15	6	PR	90
Cricotopus sp.	25	8	SH	200
Dicrotendipes sp.	1	6	CG	6
Microtendipes sp.	8	6	CF	48
Nanocladius sp.	4	3	CG	12
Parakiefferiella sp.	8	5	---	40
Polypedilum sp.	12	6	SH	72
Rheotanytarsus sp.	1	6	CF	6
Stenochironomus sp.	3	3	SH	9
Tanytarsus sp.	3	7	CF	21
Tribelos sp.	6	5	CG	30
Hemerodromia sp.	4	6	PR	24
Total # Individuals	**313**		**MBI =**	**5.4**
Total Taxa (IEPA)	**39**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**39**
Number of Coleoptera Taxa	**3**
Number of Ephemeroptera Taxa	**2**
Number of Intolerant Taxa (TV ≤ 3.0)	**9**
Macroinvertebrate Biotic Index (MBI)	**5.4**
Percent Individuals as Scrapers (FFG=SC)	**8.0%**
Percent Individuals as EPT	**18.2%**

Table 3-14. Station CAR002West mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Oligochaeta - Grouped	1	10	CG	10
Ephemeroptera				
Baetis sp.	4	4	CG	16
Isonychia sp.	1	3	CF	3
Tricorythodes sp.	7	5	CG	35
Odonata				
Hetaerina sp.	11	3	PR	33
Megaloptera				
Corydalus sp.	1	3	PR	3
Trichoptera				
Ceratopsyche sp.	50	4	CF	200
Cheumatopsyche sp.	65	6	CF	390
Hydropsyche sp.	50	5	CF	250
Hydroptila sp.	22	2	SC	44
Oecetis sp.	1	5	PR	5
Polycentropodidae	5	3.5	CF	17.5
Neureclipsis sp.	2	3	CF	6
Polycentropus sp.	1	3	PR	3
Lepidoptera				
Petrophila sp.	1	5	SC	5
Coleoptera (less semi-aquatics)				
Elmidae	1	5	CG	5
Dubiraphia sp.	6	5	CG	30
Stenelmis sp.	12	7	SC	84
Diptera				
Brillia sp.	1	6	SH	6
Cardiocladius sp.	10	6	PR	60
Conchapelopia sp.	6	6	PR	36
Cricotopus sp.	3	8	SH	24
Microtendipes sp.	1	6	CF	6
Nilothauma sp.	3	3	---	9
Polypedilum sp.	17	6	SH	102
Rheotanytarsus sp.	3	6	CF	18
Stenochironomus sp.	3	3	SH	9
Tribelos sp.	3	5	CG	15
Hemerodromia sp.	2	6	PR	12
Simulium sp.	21	6	CF	126
Total # Individuals	**314**		**MBI =**	**5.0**
Total Taxa (IEPA)	**30**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**30**
Number of Coleoptera Taxa	**3**
Number of Ephemeroptera Taxa	**3**
Number of Intolerant Taxa (TV $\leq$ 3.0)	**8**
Macroinvertebrate Biotic Index (MBI)	**5.0**
Percent Individuals as Scrapers (FFG=SC)	**11.1%**
Percent Individuals as EPT	**66.2%**

Table 3-15. Station CAR003East mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Physella sp.	1	9	SC	9
Ephemeroptera				
Baetis sp.	52	4	CG	208
Stenonema sp.	10	4	SC	40
Stenacron sp.	1	4	SC	4
Isonychia sp.	6	3	CF	18
Tricorythodes sp.	1	5	CG	5
Odonata				
Boyeria sp.	1	3	PR	3
Hetaerina sp.	1	3	PR	3
Megaloptera				
Corydalus sp.	3	3	PR	9
Trichoptera				
Ceratopsyche sp.	23	4	CF	92
Cheumatopsyche sp.	31	6	CF	186
Hydropsyche sp.	53	5	CF	265
Hydroptila sp.	26	2	SC	52
Nectopsyche sp.	1	3	SH	3
Oecetis sp.	2	5	PR	10
Polycentropus sp.	5	3	PR	15
Lepidoptera				
Petrophila sp.	7	5	SC	35
Coleoptera (less semi-aquatics)				
Dubiraphia sp.	3	5	CG	15
Macronychus sp.	6	2	---	12
Optioservus sp.	2	4	SC	8
Stenelmis sp.	16	7	SC	112
Diptera				
Brillia sp.	3	6	SH	18
Cardiocladius sp.	17	6	PR	102
Conchapelopia sp.	3	6	PR	18
Cricotopus sp.	6	8	SH	48
Dicrotendipes sp.	1	6	CG	6
Nilothauma sp.	1	3	---	3
Orthocladius sp.	1	4	CG	4
Polypedilum sp.	19	6	SH	114
Rheotanytarsus sp.	3	6	CF	18
Tribelos sp.	1	5	CG	5
Hemerodromia sp.	1	6	PR	6
Simulium sp.	14	6	CF	84
Total # Individuals	**321**		**MBI =**	**4.8**
Total Taxa	**33**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**33**
Number of Coleoptera Taxa	**4**
Number of Ephemeroptera Taxa	**5**
Number of Intolerant Taxa (TV $\leq$ 3.0)	**9**
Macroinvertebrate Biotic Index (MBI)	**4.8**
Percent Individuals as Scrapers (FFG=SC)	**19.6%**
Percent Individuals as EPT	**65.7%**

Table 3-16. Station CAR003West mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Turbellaria - Grouped	1	**6**	PR	**6**
Sphaeriidae (Grouped)	1	5	CG	5
Elimia sp.	1	6	SC	6
Fossaria sp.	1	7	SC	7
Oligochaeta - Grouped	1	10	CG	10
Caecidotea sp.	12	6	CG	72
Cambaridae - Grouped	2	5	CG	10
Ephemeroptera				
Baetis sp.	5	4	CG	20
Heptageniidae	7	3.5	SC	24.5
Stenonema sp.	1	4	SC	4
Stenacron sp.	1	4	SC	4
Isonychia sp.	4	3	CF	12
Tricorythodes sp.	15	5	CG	75
Odonata				
Boyeria sp.	2	3	PR	6
Hetaerina sp.	2	3	PR	6
Macromia sp.	1	3	PR	3
Megaloptera				
Corydalus sp.	2	3	PR	6
Trichoptera				
Ceratopsyche sp.	40	4	CF	160
Cheumatopsyche sp.	67	6	CF	402
Hydropsyche sp.	19	5	CF	95
Hydroptila sp.	23	2	SC	46
Leptoceridae	1	3.5	CG	3.5
Nectopsyche sp.	2	3	SH	6
Oecetis sp.	3	5	PR	15
Neureclipsis sp.	4	3	CF	12
Coleoptera (less semi-aquatics)				
Helichus sp.	2	4	SH	8
Ancyronyx sp.	1	2	CG	2
Dubiraphia sp.	9	5	CG	45
Macronychus sp.	3	2	---	6
Stenelmis sp.	22	7	SC	154
Diptera				
Ablabesmyia sp.	2	6	CG	12
Brillia sp.	1	6	SH	6
Cardiocladius sp.	12	6	PR	72
Chironomus sp.	1	11	CG	11
Conchapelopia sp.	14	6	PR	84
Cricotopus sp.	8	8	SH	64
Cryptochironomus sp.	1	8	PR	8
Microtendipes sp.	2	6	CF	12
Parametriocnemus sp.	2	4	CG	8
Polypedilum sp.	22	6	SH	132
Rheocricotopus sp.	1	6	CG	6
Rheotanytarsus sp.	6	6	CF	36
Tanytarsus sp.	2	7	CF	14
Hemerodromia sp.	2	6	PR	12
Simulium sp.	10	6	CF	60
Total # Individuals	**341**		**MBI =**	**5.2**
Total Taxa	**45**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**45**
Number of Coleoptera Taxa	**5**
Number of Ephemeroptera Taxa	**6**
Number of Intolerant Taxa (TV ≤ 3.0)	**10**
Macroinvertebrate Biotic Index (MBI)	**5.2**
Percent Individuals as Scrapers (FFG=SC)	**16.4%**
Percent Individuals as EPT	**56.3%**

Table 3-17. Station CAR004East mIBI Dataset - Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Sphaeriidae (Grouped)	3	5	CG	15
Pleuroceridae	2	6	---	12
Fossaria sp.	1	7	SC	7
Physella sp.	16	9	SC	144
Caecidotea sp.	11	6	CG	66
Cambaridae - Grouped	2	5	CG	10
Ephemeroptera				
Baetis sp.	39	4	CG	156
Heptageniidae	2	3.5	SC	7
Leucrocuta sp.	1	3	SC	3
Stenonema sp.	3	4	SC	12
Isonychia sp.	1	3	CF	3
Tricorythodes sp.	20	5	CG	100
Odonata				
Boyeria sp.	2	3	PR	6
Hetaerina sp.	4	3	PR	12
Trichoptera				
Ceratopsyche sp.	63	4	CF	252
Cheumatopsyche sp.	10	6	CF	60
Hydropsyche sp.	12	5	CF	60
Hydroptila sp.	6	2	SC	12
Oecetis sp.	2	5	PR	10
Lepidoptera				
Petrophila sp.	2	5	SC	10
Coleoptera (less semi-aquatics)				
Helichus sp.	1	4	SH	4
Elmidae	4	5	CG	20
Dubiraphia sp	12	5	CG	60
Macronychus sp.	5	2	---	10
Optioservus sp.	1	4	SC	4
Stenelmis sp.	23	7	SC	161
Gyrinus sp.	1	4	PR	4
Ectopria sp.	1	4	SC	4
Diptera				
Conchapelopia sp.	4	6	PR	24
Cricotopus sp.	9	8	SH	72
Microtendipes sp.	3	6	CF	18
Nilotanypus sp.	2	6	PR	12
Parakiefferiella sp.	2	5	---	10
Polypedilum sp.	29	6	SH	174
Rheocricotopus sp	2	6	CG	12
Rheotanytarsus sp.	24	6	CF	144
Thienemanniella sp	2	2	CG	4
Hemerodromia sp.	1	6	PR	6
Simulium sp.	5	6	CF	30
Chrysops sp.	2	7	CG	14
Total # Individuals	**335**		**MBI =**	**5.2**
Total Taxa	**40**			

Prepared by: JAW, 12/12/10
Checked by: TEC, 09/17/10
Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**40**
Number of Coleoptera Taxa	**8**
Number of Ephemeroptera Taxa	**6**
Number of Intolerant Taxa (TV ≤ 3.0)	**7**
Macroinvertebrate Biotic Index (MBI)	**5.2**
Percent Individuals as Scrapers (FFG=SC)	**16.7%**
Percent Individuals as EPT	**47.5%**

Table 3-18. Station CAR004West mIBI Dataset- Little Vermilion River - August 11-13, 2009

Macroinvertebrate Taxa	No. of Individuals	Tolerance Value	Functional Feeding Group	TV * No.
Sphaeriidae (Grouped)	1	5	CG	5
Fossaria sp.	1	7	SC	7
Physella sp.	8	9	SC	72
Oligochaeta - Grouped	3	10	CG	30
Caecidotea sp.	1	6	CG	6
Cambaridae - Grouped	4	5	CG	20
Ephemeroptera				
Baetis sp.	45	4	CG	180
Pseudocloeon sp.	2	4	SC	8
Leucrocuta sp.	4	3	SC	12
Stenonema sp.	22	4	SC	88
Stenacron sp.	3	4	SC	12
Tricorythodes sp.	17	5	CG	85
Odonata				
Hetaerina sp.	4	3	PR	12
Megaloptera				
Corydalus sp.	1	3	PR	3
Trichoptera				
Ceratopsyche sp.	61	4	CF	244
Cheumatopsyche sp.	17	6	CF	102
Hydropsyche sp.	8	5	CF	40
Hydroptila sp.	14	2	SC	28
Nectopsyche sp.	2	3	SH	6
Lepidoptera				
Petrophila sp.	1	5	SC	5
Coleoptera (less semi-aquatics)				
Ancyronyx sp.	1	2	CG	2
Dubiraphia sp.	6	5	CG	30
Macronychus sp.	1	2	---	2
Stenelmis sp.	7	7	SC	49
Gyrinus sp.	2	4	PR	8
Diptera				
Cladotanytarsus sp.	1	7	CG	7
Conchapelopia sp.	4	6	PR	24
Cricotopus sp.	24	8	SH	192
Cryptochironomus sp.	1	8	PR	8
Dicrotendipes sp.	5	6	CG	30
Eukiefferiella sp.	2	4	CG	8
Microtendipes sp.	6	6	CF	36
Paracladopelma sp.	1	4	CG	4
Parakiefferiella sp.	3	5	---	15
Parametriocnemus sp.	1	4	CG	4
Polypedilum sp.	18	6	SH	108
Rheocricotopus sp.	1	6	CG	6
Rheotanytarsus sp.	24	6	CF	144
Stenochironomus sp.	1	3	SH	3
Tanytarsus sp.	4	7	CF	28
Tribelos sp.	4	5	CG	20
Simulium sp.	12	6	CF	72
Chrysops sp.	3	7	CG	21
Total # Individuals	**351**		**MBI =**	**5.1**
Total Taxa (IEPA)	**43**			

Prepared by: JAW, 12/12/10

Checked by: TEC, 09/17/10

Revised by: TEC, 11/01/10

Total Number of Taxa (Genus Level)	**43**
Number of Coleoptera Taxa	**5**
Number of Ephemeroptera Taxa	**6**
Number of Intolerant Taxa (TV $\leq$ 3.0)	**8**
Macroinvertebrate Biotic Index (MBI)	**5.1**
Percent Individuals as Scrapers (FFG=SC)	**17.7%**
Percent Individuals as EPT	**55.6%**

Table 3-19. Station CAR001East mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet		Score Category			
Metric Description		Code	CAR001E Result	Best Value	Standardized Score*
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	3	5	**60**
2.	Number of Ephemeroptera Taxa	NEPH	1	10.2	**9.8**
3.	Total Taxa	TT	30	46	**65.2**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	4.8	29.6	**16.2**
5.	Percent EPT	EPT	46.8	74	**63.2**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	6	9	**66.7**
7.	Macroinvertebrate Biotic Index	MBI	5.2	4.9	**95.1**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**53.7**
IEPA Integrity Class					**Class 2**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By: JAW-11/6/2009
Checked By: TEC-9/17/2010
Revised By: TEC-11/01/2010

Table 3-20. Station CAR001West mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet		Score Category			
	Metric Description	**Code**	**CAR001W Result**	**Best Value**	**Standardized Score***
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	4	5	**80.0**
2.	Number of Ephemeroptera Taxa	NEPH	0	10.2	**0.0**
3.	Total Taxa	TT	42	46	**91.3**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	6.6	29.6	**22.3**
5.	Percent EPT	EPT	45.7	74	**61.8**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	10	9	**100.0**
7.	Macroinvertebrate Biotic Index	MBI	5.4	4.9	**91.8**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**63.9**
IEPA Integrity Class					**Class 2**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By: JAW-11/6/2009
Checked By: TEC-9/17/2010
Revised By: TEC-11/01/2010

Table 3-21. Station CAR002East mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet				**Score Category**	
Metric Description		**Code**	**CAR002E Result**	**Best Value**	**Standardized Score***
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	3	5	**60**
2.	Number of Ephemeroptera Taxa	NEPH	2	10.2	**19.6**
3.	Total Taxa	TT	39	46	**84.8**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	8.0	29.6	**27.0**
5.	Percent EPT	EPT	18.2	74	**24.6**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	9	9	**100.0**
7.	Macroinvertebrate Biotic Index	MBI	5.4	4.9	**91.8**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**58.3**
IEPA Integrity Class					**Class 2**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By:	JAW-11/6/2009
Checked By:	TEC-9/17/2010
Revised By:	TEC-11/01/2010

Table 3-22. Station CAR002West mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet				Score Category	
Metric Description		Code	CAR002W Result	Best Value	Standardized Score*
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	3	5	**60.0**
2.	Number of Ephemeroptera Taxa	NEPH	3	10.2	**29.4**
3.	Total Taxa	TT	30	46	**65.2**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	11.1	29.6	**37.5**
5.	Percent EPT	EPT	66.2	74	**89.5**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	8	9	**88.9**
7.	Macroinvertebrate Biotic Index	MBI	5.0	4.9	**98.4**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**67.0**
IEPA Integrity Class					**Class 2**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By: JAW-11/6/2009
Checked By: TEC-9/17/2010
Revised By: TEC-11/01/2010

Table 3-23. Station CAR003East mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet				Score Category	
	Metric Description	**Code**	**CAR003E Result**	**Best Value**	**Standardized Score***
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	4	5	**80**
2.	Number of Ephemeroptera Taxa	NEPH	5	10.2	**49.0**
3.	Total Taxa	TT	33	46	**71.7**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	19.6	29.6	**66.2**
5.	Percent EPT	EPT	65.7	74	**88.8**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	9	9	**100.0**
7.	Macroinvertebrate Biotic Index	MBI	4.8	4.9	**100.0**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**79.4**
IEPA Integrity Class					**Class 1**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By:	JAW-11/6/2009
Checked By:	TEC-9/17/2010
Revised By:	TEC-11/01/2010

Table 3-24. Station CAR003West mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet				Score Category	
Metric Description		Code	CAR003W Result	Best Value	Standardized Score*
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	5	5	**100**
2.	Number of Ephemeroptera Taxa	NEPH	6	10.2	**58.8**
3.	Total Taxa	TT	45	46	**97.8**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	16.4	29.6	**55.4**
5.	Percent EPT	EPT	56.3	74	**76.1**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	10	9	**100.0**
7.	Macroinvertebrate Biotic Index	MBI	5.2	4.9	**95.1**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**83.3**
IEPA Integrity Class					**Class 1**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By:	JAW-11/6/2009
Checked By:	TEC-9/17/2010
Revised By:	TEC-11/01/2010

Table 3-25. Station CAR004East mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet				**Score Category**	
Metric Description		**Code**	**CAR004E Result**	**Best Value**	**Standardized Score***
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	8	5	**100**
2.	Number of Ephemeroptera Taxa	NEPH	6	10.2	**58.8**
3.	Total Taxa	TT	40	46	**87.0**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	16.7	29.6	**56.4**
5.	Percent EPT	EPT	47.5	74	**64.2**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	7	9	**77.8**
7.	Macroinvertebrate Biotic Index	MBI	5.2	4.9	**95.1**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**77.0**
IEPA Integrity Class					**Class 1**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By: JAW-11/6/2009
Checked By: TEC-9/17/2010
Revised By: TEC-11/01/2010

Table 3-26. Station CAR004West mIBI Score and Integrity Class - Little Vermilion River.

Illinois EPA - Index of Biotic Integrity Index Worksheet		Score Category			
	Metric Description	Code	CAR004W Result	Best Value	Standardized Score*
	Species Richness Metrics				
1.	Number of Coleoptera Taxa	NCOL	5	5	**100**
2.	Number of Ephemeroptera Taxa	NEPH	6	10.2	**58.8**
3.	Total Taxa	TT	43	46	**93.5**
	Trophic Structure Metrics				
4.	Percent Scraper	SC	17.7	29.6	**59.8**
5.	Percent EPT	EPT	55.6	74	**75.1**
	Pollution Tolerance Metrics				
6.	Number of Intolerant Taxa	INTOL	8	9	**88.9**
7.	Macroinvertebrate Biotic Index	MBI	5.1	4.9	**96.7**
Macroinvertebrate Index of Biotic Integrity (mIBI)					**81.8**
IEPA Integrity Class					**Class 1**
Integrity Class Descriptions [mIBI ≥41.8 Consistent with Designation of Fully Supporting Aquatic Life Use]					**Range**
Class 1 - Biotic integrity is higher than expected in Illinois streams (typical references)					73.0-100.0
Class 2 - Biotic integrity similar to that expected in Illinois streams					41.8-72.9
Class 3 - Biotic integrity lower than expected in Illinois streams					20.9-41.7
Class 4 - Biotic integrity is much lower than expected in Illinois streams					0.0-20.8

*Standardized scores are (Result-0)/(Best Value-0)*100; except in the MBI, which is (11-Result/11-Best Value)*100

Prep. By:	JAW-11/6/2009
Checked By:	TEC-9/17/2010
Revised By:	TEC-11/01/2010

Table 3-27. Summary of Macroinvertebrate Index of Biotic Integrity Scores and Integrity Classes for Sampling Stations on Little Vermilion River Illinois River Drainage, August 11-13, 2009

Illinois EPA - Index of Biotic Integrity Index Worksheet	Metric Result & Score by Station															
	CAR004-West Bank		CAR004-East Bank		CAR003-West Bank		CAR003-East Bank		CAR002-West Bank		CAR002-East Bank		CAR001-West Bank		CAR001-East Bank	
Metric Description	Result	Standardized Score	Result	Standardized Score	Result	Standardized Score	Result	Standardized Score	Result	Standardized Score	Result	Standardized Score	Result	Standardized Score	Result	Standardized Score
Species Richness Metrics																
1. Number of Coleoptera Taxa	5	**100.0**	8	**100.0**	5	**100.0**	4	**80.0**	3	**60.0**	3	**60.0**	4	**80.0**	3	**60.0**
2. Number of Ephemeroptera Taxa	6	**58.8**	6	**58.8**	6	**58.8**	5	**49.0**	3	**29.4**	2	**19.6**	0	**0.0**	1	**9.8**
3. Total Taxa	43	**93.5**	40	**87.0**	45	**97.8**	33	**71.7**	30	**65.2**	39	**84.8**	42	**91.3**	30	**65.2**
Trophic Structure Metrics																
4. Percent Scraper	17.7	**59.8**	16.7	**56.4**	16.4	**55.4**	19.6	**66.2**	11.1	**37.5**	8.0	**27.0**	6.6	**22.3**	4.8	**16.2**
5. Percent EPT	55.6	**75.1**	47.5	**64.2**	56.3	**76.1**	65.7	**88.8**	66.2	**89.5**	18.2	**24.6**	45.7	**61.8**	46.8	**63.2**
Pollution Tolerance Metrics																
6. Number of Intolerant Taxa	8	**88.9**	7	**77.8**	10	**100.0**	9	**100.0**	8	**88.9**	9	**100.0**	10	**100.0**	6	**66.7**
7. Macroinvertebrate Biotic Index (MBI)	5.1	**96.7**	5.2	**95.1**	5.2	**95.1**	4.8	**100.0**	5.0	**98.4**	5.4	**91.8**	5.4	**91.8**	5.2	**95.1**
Macroinvertebrate Index of Biotic Integrity (mIBI) Score		**81.8**		**77.0**		**83.3**		**79.4**		**67.0**		**58.3**		**63.9**		**53.7**
IEPA Integrity Class		**Class 1**		**Class 1**		**Class 1**		**Class 1**		**Class 2**		**Class 2**		**Class 2**		**Class 2**

Macroinvertebrate Index of Biotic Integrity (mIBI)	**Range**
Class 1 - Biotic integrity is higher than expected	73.0-100.0
Class 2 - Biotic integrity similar to that expected	41.8-72.9
Class 3 - Biotic integrity lower than expected	20.9-41.7
Class 4 - Biotic integrity is much lower than expected	0.0-20.8

Prepared by:	JAW
Date:	12/15/2009
Checked by:	TEC
Date:	11/1/2010

Table 3-28. Analytical Results - BioticTissues
Samples Collected from the Little Vermilion River (Illinois River Basin) August 11-13, 2009

MG/KG - Dry Wt.	CAR004							CAR003						
Species	As	Cd	Cu	Pb	Hg	Ag	Zn	As	Cd	Cu	Pb	Hg	Ag	Zn
Fish														
Northern hogsucker-WB	0.29	0.176	4.29	0.156	0.125	0.02	92.1	0.20	0.313	9.93	0.566	0.13	0.031	135
Smallmouth bass -WB	0.53	0.207	3.71	0.113	0.125	0.035	74.6	0.24	0.111	4.77	0.294	0.231	0.02	81.4
Sauger - WB	--	--	--	--	--	--	--	0.17	0.088	18.6	0.619	0.306	0.019	75.0
Sauger - FL	--	--	--	--	--	--	--	0.13	0.008	1.20	0.009	0.994	0.02	22.3
Mussel [1,2]														
Plain pocketbook	--	--	--	--	--	--	--	5.40	8.890	15.6	1.060	0.086	0.334	6300

	CAR002							CAR001						
Species	As	Cd	Cu	Pb	Hg	Ag	Zn	As	Cd	Cu	Pb	Hg	Ag	Zn
Fish														
Northern hogsucker-WB	0.24	0.538	9.46	0.909	0.268	0.076	219	0.34	0.369	6.72	1.520	0.160	0.079	175
Smallmouth bass-WB	0.21	0.188	3.65	0.354	0.314	0.025	106	0.57	0.233	7.73	0.344	0.356	0.019	93.6
Smallmouth bass-FL	--	--	--	--	--	--	--	0.67	0.018	0.94	0.011	1.09	0.02	26.2
Mussel														
Plain pocketbook	3.77	8.810	18.3	1.480	0.120	0.332	5990	5.02	5.420	7.14	0.96	0.067	0.107	1650

Notes:

[1] Only one live mussel specimen was collected at each sample location….among many relic shells; some "fresh dead"

[2] A single live Ellipse (*Venustaconcha ellipsiformis*) was collected at the reference location. As a state "species of special concern", it was released.

APPENDIX A

Field Sampling Plan, Addendum No. 1 (Revision 1) – Matthiessen and Hegeler Zinc Company

Prepared for:

Carus Corporation and
Carus Chemical Company

1500 Eighth Street
P.O. Box 1500
LaSalle, Illinois 61301-3500

FIELD SAMPLING PLAN ADDENDUM NO. 1 (Revision 1)

PHASE 2 OF THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY, OPERABLE UNIT 1

MATTHIESSEN AND HEGELER ZINC COMPANY SITE LASALLE, ILLINOIS

Prepared by:

Geosyntec consultants

engineers | scientists | innovators

1200 Riverplace Boulevard, Suite 710
Jacksonville, Florida 32207

Geosyntec Consultants Project Number FR1347T
April 2009

This Field Sampling Plan Addendum No. 1 for the Remedial Investigation/Feasibility Study at the Matthiessen and Hegeler Zinc Company Site in LaSalle, Illinois has been prepared by Geosyntec Consultants and reviewed by the following:

Prepared by: Teresa A. Fischer — 13 April 2009

Teresa A. Fischer — Date

Reviewed by: Peter J. de Haven — 13 April 2009

Peter J. de Haven. P.E. — Date
Data Management Lead

Nandra D. Weeks — 13 April 2009

Nandra D. Weeks, P.E. — Date
Project Manager

Brief Description of Amendment	Amendment Date

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

TABLE OF CONTENTS (continued)

LIST OF ACRONYMS ABD ABBREVIATIONS

ASAOC	Administrative Settlement Agreement and Order on Consent
BERA	Baseline Ecological Risk Assessment
BLS	Below Land Surface
Carus	Carus Chemical Company
CAS	Columbia Analytical Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of Concern
COPC	Chemical of Potential Concern
CSO	Combined Sewer Overflow
DC	Direct Current
DO	Dissolved Oxygen
DQO	Data Quality Objective
FS	Feasibility Study
FSP	Field Sampling Plan
ft	Feet
Geosyntec	Geosyntec Consultants
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HHRA	Human Health Risk Assessment
IBI	Index of Biotic Integrity
ICRR	Illinois Central Railroad
ID	Identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
M&H	Matthiessen and Hegeler
µmhos/cm	Micromhos Per Centimeter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ORP	Oxidation-Reduction Potential
OU1	Operable Unit 1
OU2	Operable Unit 2

TABLE OF CONTENTS (continued)

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

PCB	Polychlorinated Biphenyl
PFD	Personal Flotation Device
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SCI	Stream Condition Index
SEP	Sequential Extraction Procedure
SLERA	Screening Level Ecological Risk Assessment
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semi-Volatile Organic Compound
TACO	Tiered-Approach to Cleanup Objectives
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

1. INTRODUCTION

1.1 Terms of Reference

This Field Sampling Plan (FSP) Addendum has been prepared as part of the Remedial Investigation/Feasibility Study (RI/FS) for the Matthiessen and Hegeler (M&H) Zinc Company Site (Site) located in LaSalle, Illinois. The RI/FS is required by an Administrative Settlement Agreement and Order on Consent (ASAOC), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Docket No.V-W-06-C-856, dated 6 October 2006, between United States Environmental Protection Agency (USEPA) Region V, Carus Corporation, and Carus Chemical Company (Carus), pursuant to the CERCLA. During the course of the RI/FS, environmental samples will be collected to: (i) characterize the nature and extent of any contamination stemming from past site practices, as well as the risks to human health and the environment stemming there from; and (ii) develop and evaluate remedial alternatives for the Site. This FSP Addendum is written to provide the details for field sampling locations and procedures and will be most frequently used by field staff on-site during the Phase 2 investigation.

This FSP Addendum No. 1 is one of three RI/FS Planning Documents submitted concurrently in fulfillment of Task 1.3 of the ASAOC. Other, concurrently submitted planning documents include the following:

- RI/FS Work Plan Addendum No. 1 (Revision 1), which provides an overview of the Phase 2 RI/FS scope of work proposed for Operable Unit 1 (OU1); and

- Quality Assurance Project Plan (QAPP) Addendum No. 1 (Revision 1), written to establish protocols necessary to ensure that the data generated during Phase 2 are of a quality sufficient to ensure that valid conclusions are drawn from the site data (Appendix B of this submittal).

The Health and Safety Plan (HASP) and Standard Operating Procedures (SOPs) to be used during the Phase 2 investigation were submitted as Appendices C and D of the Planning Documents submittal in July 2007. These documents have been approved by USEPA.

1.2 Overview of the RI

1.2.1 Introduction

Phase 1 of the field activities was conducted in October 2007 through January 2008 for OU1 in fulfillment of RI/FS requirements set forth in the Statement of Work in Appendix A of the ASAOC. OU1 is a portion of the broader M&H Site, located on the east side of LaSalle, Illinois. The Site encompasses approximately 183 acres of defined property plus any off-property areas, such as the Little Vermilion River, which may have been affected by the Site's manufacturing history. The Site is divided into two operable units: (i) OU1, comprising the Carus facility in the southern portion of the site, the slag pile created from M&H operations, and the Little Vermilion River; and (ii) Operable Unit 2 (OU2), comprising the former M&H Zinc Company in the northern portion of the site, as well as any impacts to residential or other areas in the City of LaSalle. The ASAOC requires Carus' participation in a site-wide RI/FS, which, for Carus, specifically entails: (i) performing OU1-related activities; and (ii) combining investigative findings from OU1 with those from OU2 provided by USEPA's contractor into site-wide reports.

1.2.2 Phase 1 Scope of Work

The Phase 1 scope of work and the results were summarized in a Data Evaluation Report dated April 2008. The scope of work included the following general investigative programs:

- **Solid Matrix Characterization Program** - Solid matrix samples were collected from soil borings at ten locations in the slag pile area and eight locations in the main plant area. The laboratory results for soil samples were compared to the USEPA Region 9 Preliminary Remediation Goals (PRG) for Soil – October 2004, and the Illinois Environmental Protection Agency (IEPA) Tiered Approach to Corrective Action Objectives (TACO) Tier 1 Soil Remediation Objectives for Industrial/Commercial Properties – February 2007.

- **Surface Water and Sediment Characterization Program** - Surface water samples were collected at eight locations along the Little Vermilion River. The laboratory results for surface water samples were compared to USEPA Region 5 Ecological Screening Levels for Surface Water – August, 2003. Sediment samples were collected at 15 locations in the Little Vermilion River. The laboratory results for sediment samples were compared to USEPA Region 5 Ecological Screening Levels for Sediment – August, 2003. To quantify the slag mass fraction of Little Vermilion River sediment, grab samples were collected at 20 locations. No slag was detected upstream of OU2, but slag was detected along OU2, increasing in percentage along the slag pile area with a continued presence to the confluence of the Little Vermilion and Illinois Rivers.

Little significant surface water accumulation was observed upland of the Little Vermilion River at OU1 during field activities and following observed storm events (although storm events during the RI/FS were relatively mild). A sporadic seep was observed emanating from the sinter pile (also referred to as the ash disposal area on historic M&H Zinc Company maps). A sediment sample was collected at the sporadic seep location (no seep was observed during the sampling event). The analytical program for the sample consisted of Target Analyte List (TAL) metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, and cyanide.

- **Groundwater Characterization Program** - Groundwater sampling was conducted at 15 monitoring wells during the months of December 2007 and January 2008. The laboratory results for groundwater samples were compared to USEPA Region 9 PRGs for Tapwater – October 2004, and IEPA TACO Tier 1 Soil Remediation Objectives for the Soil Component of the Groundwater Ingestion Route for a Class II Aquifer – February 2007. Potentiometric surface maps were constructed from site-wide water level readings from slag, alluvium, and bedrock monitoring wells. The groundwater flow direction in OU1 is primarily towards the Little Vermilion River. Little to no groundwater was observed in monitoring wells screened in slag. Throughout the RI/FS, groundwater levels were lower than previous observations. The decrease in groundwater level may be partially due to repair in the piping infrastructure that directs non-contact cooling water and surface runoff from the main plant area to the OU1 retention pond (historically, the pipes have leaked).

- **Ecological Habitat Characterization Program** - The ecological habitat was characterized at OU1. The Carus main plant area of OU1 is characterized as an active industrial complex dominated by building structures and impervious surfaces that provide little or no ecological habitat. The main plant area will remain that way for the foreseeable future. The slag pile area of OU1 is characterized as highly disturbed; selected areas are in recovery. Some terrestrial habitats are present and support mammalian and avian receptors. The Little Vermilion River and associated riparian area is the most prominent ecological habitat feature of the site.

1.3 Goals and Objectives

The overall goal of the RI/FS process is to collect sufficient data to characterize the extent of contamination at the site, support the human health and ecological risk assessments, and support a FS for a range of potential remedial options leading to USEPA's selection of a proposed remedial action for the Site.

Historic site investigation data along with the Phase 1 RI data provide information that will be used to evaluate potential exposure pathways and to evaluate potential remedial alternatives protective of human health and the environment. Data collected during the RI, in addition to historic data, will be utilized to meet the specific objectives described in Section 5 of the RI/FS Work Plan. Based on the information obtained during Phase 1 of the RI/FS, additional information is warranted to more fully characterize the site. The work scope presented in this FSP Addendum was developed to provide that information.

The objectives of this FSP Addendum are the following:

- present the rationale for the number and types of environmental samples to be collected during the Phase 2 field investigation;
- present the rationale for the selection of sampling locations;
- describe the procedures to be used for collection, preservation, packaging, and transport of environmental samples;
- present documentation requirements for sample activities and sample custody; and
- describe the procedures for decontamination of environmental sampling equipment.

The FSP Addendum has been prepared primarily for use by field personnel to ensure sample collection and analytical activities are conducted in accordance with technically accepted protocols and the data meet site-specific Data Quality Objectives (DQOs) established in the QAPP. Accordingly, the intent of this FSP Addendum is to provide the procedures required to implement the program outlined in the RI/FS Work Plan Addendum for the Site. The Phase 2 fieldwork was developed based on the results of the initial phase of RI fieldwork and reflects discussions during the meeting held with the USEPA on 6 and 7 March 2008. The Phase 2 scope was developed to provide information to answer the following questions:

- What is a representative, average concentration of contaminants of concern (COCs) in sediment and surface water at various locations in the river (spatial distribution)?

- Does additional sampling confirm or refute the observed increase in some metals concentrations at locations along the slag pile, as compared to the samples upstream of the slag pile, and if so, what is the cause of any confirmed increase in metals concentrations?

- What are the metals concentrations in sediment and surface water downstream of the 5th Street Bridge?

- What are the metals concentrations in pore water at the interface of the slag pile and the Little Vermilion River (which will be called interstitial water for purposes of this RI/FS)?

- Do the concentrations of COCs, principally certain metals, in the river pose a threat or concern to the biota?

2. PHASE 2 FIELD ACTIVITIES

2.1 Mobilization and Site Access

2.1.1 Pre-Investigation Activities

Much of the Phase 2 field investigation activities will take place continuously over the course of several weeks. To ensure that the fieldwork is executed in an efficient manner, the following tasks, at a minimum, should be completed prior to conducting field activities:

- coordinate the project schedule and provide notification to USEPA, USEPA contractors (e.g., SulTRAC), and IEPA;
- contact the laboratory to review analytical requirements, provide sample containers, and discuss delivery and pickup of coolers and packages;
- contact subcontractors (as may be needed) to review the scope of work, schedule field activities, and discuss special equipment needs;
- order field supplies and secure specialized equipment needed to complete field activities;
- provide copies of project documents to field personnel; and
- review the scope of work with the Project Manager to identify any potential issues that need to be addressed prior to implementation of the work.

All sampling work that applies to both OU1 and OU2, such as surface water sampling, will be scheduled and conducted in conjunction with SulTRAC.

2.1.2 Site Access Control

Site access control is of the highest importance to protect the public from potential exposure to chemicals at the Site during RI/FS Phase 2 field investigation activities. All visitors to the Carus facility must check in daily at the front office and be badged. The main plant area is fenced and access is controlled by gates. During the work day, access is limited to one open gate (the main entryway); however, this gate is closed at night. All visitors must check in with the Field Manager before being allowed to enter work areas. Visitor information (e.g., affiliation, reason for access, etc.) will be documented in the field log book. Unauthorized visitors will not be allowed to enter work areas. Visitors will only be allowed to enter the exclusion zone with permission from the Site Health and Safety Officer (SHSO). Where applicable, proof of Hazardous Waste Operations and Emergency Response (HAZWOPER) training and evidence of participation in a medical surveillance program will be required before being allowed to enter the work area. Specifically, for on-site work and off-site work areas where reference samples for sediments and surface water will be collected, visitors will be required to present to the SHSO: (i) a copy of their completion certificates for 40-hour HAZWOPER training and 8-hour refresher training; and (ii) evidence of participation in a medical surveillance program for inclusion in the Health and Safety Plan (HASP). All personnel entering the Site will review and sign the HASP.

2.1.3 Field Standard Operating Procedures

SOPs referenced in this document are listed below. The individual SOPs are included in Appendix D of the RI/FS Planning Documents (July 2007)

SOP No.	Description
100	Water Level Measurement Procedures
110	Groundwater Sampling Using the Low-Flow Protocol
120	Construction of Monitoring Wells
130	Monitoring Well Development
200	Surface Soil Sampling
300	Surface Water and Sediment Sampling
410	Packaging and Shipping of Environmental Samples

2.2 Temporary Monitoring Well Installation and Development

Three temporary monitoring wells, ISW-001, ISW-002, and ISW-003, will be installed in the shallow subsurface to obtain samples of interstitial water. Temporary monitoring well locations are shown in Figure 1, although exact locations will be determined in the field by Geosyntec and SulTRAC personnel based on field conditions. The wells will be located near the interface of the slag pile and the Little Vermilion River to assess the concentrations of metals within the pore water, and also to measure the water table at this interface in order to evaluate potential contributions from groundwater to surface water in the Little Vermilion River. Access issues prohibit heavy equipment usage for the installation of permanent groundwater monitoring wells between the slag pile and the Little Vermilion River. Construction of boreholes for the temporary wells will be attempted first using a hand auger. If subsurface conditions preclude advancement using a hand auger, picks and shovels will be used to create a void for placement of a pre-pack well screen. The specific manufacturer will be determined subsequent to submittal of the Work Plan in discussions with USEPA and SulTRAC (the decision will be documented in a technical memorandum prepared by Geosyntec to USEPA prior to installation of the temporary wells).

Field personnel will endeavor to advance each borehole to a depth of three to five ft below land surface (BLS). Pre-pack wells screens will be utilized to build the temporary wells. The well screen will be 2.5 ft in length with a 2-inch nominal inside diameter casing. The pre-pack well will be placed vertical in the hole and the annular space filled with natural material originally removed from the borehole or alternatively filled with sand if the natural material is not suitable to fill the annular space due to large size particles or irregularity in shape. If sand is used, it will be consistent with that used throughout the site for construction of monitoring wells (see SOP No. 120). The temporary monitoring wells will be removed following the sampling event. Well screen depth will be determined in the field based on the depth of the water table. To the extent practical given subsurface conditions, well screens will be fully submerged below the water table. The top of casing and the ground surface of each temporary well will be surveyed for horizontal and vertical control by a State of Illinois registered land surveyor. Horizontal control is based on Illinois State Plane - East, North American Datum (NAD) of 1983. Elevation measurements are based on National Geodetic Vertical Datum (NGVD) of 1929. Elevations of the interstitial water in each well and the river adjacent to each temporary well will be collected to establish flow conditions. Temporary monitoring wells will be developed prior to sampling. Wells will be developed using decontaminated or dedicated sampling equipment to reduce the possibility of cross-contamination. Purge water collected during well development will be containerized and disposed of as described in Section 5 of the original FSP (May 2007). Procedures for monitoring well development are described in SOP No. 130.

2.3 River Characterization Program

The River Characterization Program is designed to further characterize sediment and surface water within the Little Vermilion River, evaluate two identified point sources to assess potential releases to the Little Vermilion River, and characterize interstitial water from the slag pile/Little Vermilion River interface. The two point sources are the abandoned sewer and the active Combined Sewer Overflow (CSO) outfall. The Little Vermilion River Characterization Program consists of sediment and surface water sampling and analysis, which will be conducted to provide information for the Screening Level Ecological Risk Assessment (SLERA) and the Human Health Risk Assessment (HHRA), and interstitial water sampling which will be conducted to evaluate potential contributions to surface water within the Little Vermilion River.

Sample analysis for sediment, surface water, and interstitial water includes the 23 metals on the TAL with seven metals of potential concern (arsenic, cadmium, copper, lead, mercury, silver, and zinc) analyzed using USEPA Methods 6020A/7470A/7471B for low level analysis. These metals were selected primarily based on the results of the Little Vermilion River sampling event performed during the Phase 1 investigation. Arsenic, cadmium, copper, lead, silver, and zinc were measured at levels above USEPA Region 5 Ecological Screening Levels at one or more sediment or surface water locations. Mercury was added to the list for low level analysis due to USEPA's concerns about the presence of mercury and the detection of mercury in site media during previous investigations. Surface water and interstitial water samples will also be analyzed for hardness. Both total (unfiltered) and dissolved (filtered) surface water and interstitial water samples will be collected and analyzed. Dissolved samples will be filtered in the field.

2.3.1 Sample Location and Frequency

Sediment Sampling Locations

A total of 19 sediment samples will be collected from nine depositional areas within the Little Vermilion River (LVR-401 through LVR-409), as shown on Figure 1. The locations for sediment sampling include: (i) three downgradient of the site (LVR-401, LVR- 402, and LVR-403); (ii) two adjacent to the slag pile area (LVR-404 and LVR-405); (iii) one downstream of the active CSO outfall (LVR-406); (iv) one location where the creek flowing from the abandoned sewer discharges to the Little Vermilion River (LVR-407); (v) one upgradient of the dam sufficiently upstream to avoid potential impacts from the dam (LVR-408); and (vi) one upstream sample (LVR-409). Two sediment samples located upstream of the slag pile (LVR-408, and LVR-409) will be collected using a three-point composite approach within a single 10 ft diameter depositional area. Sediment types of different composition will not be combined into the same composite sample. Discrete samples will be collected from three sediment sample locations downstream of the slag pile (LVR-401, LVR-402, and LVR-403), two sediment sample locations adjacent to the slag pile (LVR-404 and LVR-405), one downstream of the active CSO (LVR-406), and one within a depositional area where the creek flowing from the abandoned sewer outfalls to the Little Vermilion River (LVR-406). Three discrete samples will be collected at five locations (LVR-401 through LVR-405) from the following areas: (i) near the western bank; (ii) near the center of the river; and (iii) near the eastern bank.

Surface Water Sampling Locations

A total of 27 surface water samples will be collected from nine locations, including seven within the Little Vermilion River (LVR-401 through LVR-405, LVR-408, and LVR-409), one from the active CSO (CSO-410), and one from the abandoned sewer (ASO-411), as shown on Figure 1. For all surface water samples, total (unfiltered) and dissolved (filtered) surface water samples will be collected to evaluate the effect of particulates on metals concentrations.

Three discrete samples will be collected from five sampling locations, including three downgradient of the slag pile (LVR-401, LVR-402, and LVR-403), and two adjacent to the slag pile (LVR-404 and LVR-405). For these locations, discrete surface water samples will be collected equidistant across a transect perpendicular to the river (one near each bank and one in the center of the river). Two surface water samples (LVR-408 and LVR-409) will be collected using a three-point composite approach along a transect perpendicular to river flow. The three-point composite samples will be equidistant across the transect (near each bank and in the center of the river). The samples will be collected as close to the sediment/ surface water interface as possible. Discrete samples will also be collected from the active CSO and the abandoned sewer as follows:

- Abandoned Sewer. Four discrete surface water samples will be collected from the point where the discharge tunnel empties into the creek leading to the Little Vermilion River. This abandoned sewer continues to discharge water to the Little Vermilion River, as it appears that the old drainage pipes lack integrity and receive groundwater from OU2. The surface water samples will be collected from the same location on four separate days. The flow rate will also be estimated at the time of sample collection. In addition, three discrete surface water samples will be collected following qualifying rain events. For the purposes of this project, a qualifying rain event is defined as a rainstorm that meets the following criteria: (i) produces 0.1 inches or more in measured rainfall in 24 hours; (ii) causes an increase in runoff to be present at the outfall; and (iii) occurs at least three days (72 hours) from the previous 0.1 inch rainfall.

- CSO Outfall. The active CSO outfall flows only sporadically; however, three discrete surface water sampling events are included in the River Characterization Program. The surface water sample will be collected at the point of discharge from the outlet to the river.

Interstitial Water Sampling Locations

Interstitial water samples will be collected from the temporary monitoring wells to be located at the slag pile/Little Vermilion River interface. These locations include ISW-001, ISW-002, and ISW-003 (Figure 1). The groundwater sampling event will be conducted during low to moderate flow conditions when the Little Vermilion River is believed to be in a gaining state. Interstitial water and surface water elevations will be compared at the time of sampling to verify flow conditions. The temporary monitoring wells will be removed following the sampling event.

2.3.2 Sample Collection Procedures

Sediment sampling will follow procedures outlined in SOP No. 300. Sediment samples will entail use of a stainless steel bowl and spoon with either a hand auger or ponar sampler employed if deep water conditions necessitate their use. Composite sediment samples will be collected using a three-point composite approach within a 10 ft diameter depositional area near the corresponding surface water sample. Sediment types of different composition will not be combined into the same composite sample.

Surface water sampling will follow procedures outlined in SOP No. 300. Surface water samples will be collected as close to the sediment/ surface water interface as possible using a horizontal sampler, if necessary due to river conditions (i.e., if the depth of river is greater than two feet (ft)). In shallower water or at point source discharge locations, a decontaminated glass measuring cup can be used to collect the surface water sample. Two surface water samples (LVR-408 and LVR-409) will be collected using a three-point composite approach along a transect perpendicular to river flow. The three-point composite samples will be equidistant across the transect (near each bank and in the center of the river). The samples will be collected as close to the sediment/ surface water interface as possible.

Total (unfiltered) and dissolved (filtered) surface water samples will be collected to evaluate the effect of particulates on metals concentrations in the Little Vermilion River water column. Dissolved samples will be filtered in the field. At the time of water sample collection, field measurements of temperature, conductivity, dissolved oxygen (DO), turbidity, pH, and oxygen reduction potential (ORP) will also be recorded.

Interstitial water samples will be collected from temporary monitoring wells located along the slag pile/Little Vermilion River interface using low flow techniques (SOP No. 110). Prior to sampling, static water levels will be measured in all site wells with a water level indicator. The procedures for using the water level indicator are described in SOP No. 100. Field-measured parameters must stabilize for purging to be complete. At least three consecutive readings spaced approximately five minutes apart must be within the following ranges for the following indicator parameters:

Indicator Parameter	Acceptable Range
Specific Conductance	±3% micromhos per centimeter (µmhos/cm)
pH	±0.1 pH units
Temperature	±10%
DO	±10% milligrams per liter (mg/L)
ORP	±10% millivolts (mV)
Turbidity	±10% nephelometric turbidity units (NTUs)

Purge volumes and color, odor, and turbidity of the groundwater in each monitoring well will be noted on the Low-Flow Sampling Protocol field form. The condition of the well will also be recorded at the time of sample collection. All details regarding interstitial water sample collection will be recorded in the field form accompanying the SOP.

Each well will be purged with either a bladder pump or a peristaltic pump. Tubing will be dedicated to the well. Field measurements for specific conductance, pH, temperature, oxidation-reduction potential (ORP), turbidity, and dissolved oxygen (DO) will be taken at the time of sample collection. The procedures for measuring groundwater field parameters and operating the equipment are detailed in SOP No. 110. A comprehensive list of sampling equipment needed to collect water samples is also listed in SOP No. 110.

Interstitial water samples will be placed in appropriate laboratory-supplied containers. Samples will be placed in containers and preserved in accordance with SOP No. 110 and the analytical requirements summarized in Table 1. Samples will be collected for both filtered and unfiltered analysis. Samples will be filtered in the field.

2.3.3 Sample Handling and Analysis

Proper field sampling documentation and field analytical and laboratory documentation helps to ensure sample authenticity and data integrity. Section 3.2 describes the methods for assigning unique sample names. The unique sample name will be used on the sample containers, sample tags, and Chain-of-Custody Record. Procedures for sample shipping are described in SOP No.

410.

The sediment, surface water, and interstitial water samples will be analyzed for the 23 metals on the TAL with seven metals of potential concern (As, Cd, Cu, Pb, Hg, Ag, and Zn) analyzed using USEPA Methods 6020A and 7470A/7471B for low level analysis. These metals were selected primarily based on the results of the Little Vermilion River sampling event performed during the Phase 1 investigation. Arsenic, cadmium, copper, lead, silver, and zinc were measured at levels above USEPA Region 5 Ecological Screening Levels at one or more sediment or surface water locations. Mercury was added to the list for low level analysis due to USEPA's concerns about the presence of mercury and also because mercury has been detected in site media during previous investigations. Surface water and interstitial water samples will also be analyzed for hardness using USEPA Methods 130.2 and 130.1.

Samples will be analyzed for TAL metals (EPA Methods 6010B/6020A/7470A/7471B), as presented in Table 1. Laboratory services will be provided by Columbia Analytical Services (CAS) in Rochester, New York.

2.4 Slag Characterization

2.4.1 Sample Location and Frequency

Slag samples will be collected from two sources of slag, the slag pile and the Little Vermilion River, and evaluated for leachability using three different tests: (i) a specialized leachability test; (ii) conventional Synthetic Precipitation Leaching Procedure (SPLP) on both sieved and unsieved samples; and (iii) Sequential Extraction Procedure (SEP) testing. Slag samples will be collected from three locations within each source of slag. The purpose of the slag leachability tests is to better understand the potential for leaching of metals from the slag into the river, as well as the potential for "weathering" of slag after protracted exposure to river water.

Samples Required for Specialized Leachability Testing

Slag samples will be collected from the three slag pile sampling locations (SLP-415, SLP-416, and SLP-417), as shown on Figure 1. The samples from the slag pile will be collected from the steepest angle of repose, if accessible and deemed to be safe. Alternatively, the samples will be collected approximately five ft above the river level. The samples from the slag pile will be collected from: (i) near the northern extent of the slag pile (SLP-417); (b) 500 ft south of the northern extent (SLP-416); and (iii) 1,000 ft south of the northern extent of the slag pile (SLP-415). Soil sieves will be used to process one sample from each location, resulting in a sample that contains material that passes a 1-inch sieve, but is retained on a ¼ inch sieve. This procedure should result in a sample that is similar to the typical size of slag observed in the Little Vermilion River during the physical characterization performed in October, 2007. (Note that during Phase 1 of the RI, the sediment samples adjacent to and downstream of the slag pile contained about 10 to 30% slag. Of that slag fraction, greater than 50% of the slag was of the size between ¼-inch and 1-inch in diameter.) Slag pieces of this grain size interval are anticipated to be of sufficient size to be distinguishable from native materials by trained field personnel. Native materials will be manually separated from slag materials. Sieved materials that are not slag, such as pieces of brick, debris, or native material, will be removed from the sample.

Slag samples will be collected from three locations within the Little Vermilion River (LRS-412, LRS-413, and LRS-414), as shown in Figure 1. The samples collected from the Little Vermilion River will be located in the general vicinity as the sediment samples collected from depositional areas. Soil sieves will be used to process one sample from each location, resulting in a sample that contains material that passes a 1-inch sieve, but is retained on a ¼ inch sieve. Native materials will be manually separated from slag materials. The slag samples from within the Little Vermilion River will be collected from locations adjacent to the slag pile, south of the 5th Street Bridge, and north of the concrete plant to better assess how the slag leachability may vary with location in the river (and likely residence time within the river assuming that the age of the slag increases generally with distance from the site).

Samples Required for Conventional SPLP and SEP Testing

In addition to the specialized leachability test, three sieved samples will be collected, sieved, and sorted as described above for additional testing, including conventional SPLP and SEP testing. These samples will include one sample collected from the slag pile (SLP-415) and two collected from the Little Vermilion River (LRS-412 and LRS-413). The sieved slag samples subjected to conventional SPLP and the SEP testing will be analyzed for the 23 TAL metals. In addition, from each of these three locations, a sample will be collected and will not be sieved or sorted (i.e., it will remain intact). The unsieved slag samples will be subjected to conventional SPLP testing and will be analyzed for the 23 TAL metals.

2.4.2 Slag Sample Collection Procedures

2.4.2.1 Slag Pile Samples

Three grab slag samples will be collected from the slag pile (SLP-415 through SLP-417) using a stainless steel shovel, hand auger, trowel, and/or spatula in general accordance with SOP No. 200. A portion of the sample collected from the SLP-415 location will be analyzed without sieving in accordance with conventional SPLP procedures, followed by analysis for the 23 TAL metals. The slag samples will be screened by hand (in lieu of a mechanical shaker) in the field using conventional 12-in diameter round sieves commonly used for grain size determination (sieve analysis). Two sieves (¼-inch and 1-inch screen size), a pan, and a lid will be required. The samples will be screened through the sieves. The slag samples will consist of pieces of slag that pass through a 1 inch sieve but are retained by a ¼ inch sieve. This methodology should result in a sample that is similar to the typical size of slag observed in the Little Vermilion River during the physical characterization performed in October, 2007. Slag pieces of this grain size interval should be of sufficient size to be distinguishable from native materials by trained field personnel. Native materials will be manually separated from slag materials. Sieved materials that are not slag, such as pieces of brick, debris, or native material, will be removed from the sample. Each slag sample will be double bagged in a Ziploc® bag and shipped to the lab for leachability testing. Each sample must be of sufficient volume (3.5 Kg) to perform leachability tests using two different solutions, in triplicate. In addition, one slag sample from the slag pile (SLP-415) must also be collected in sufficient volume to sieve the sample, separate the native material from the slag, and perform an SPLP extraction and an SEP on the sample for subsequent analysis of TAL metals (600 grams of slag is needed to perform these analyses). In addition, slag (unsieved and unsorted) will be collected in sufficient volume to perform an SPLP extraction for subsequent analysis of TAL metals.

2.4.2.2 Little Vermilion River Samples

Slag samples collected from the river (LRS-412 through LRS-414) will follow procedures outlined in SOP No. 300. Sediment samples will entail use of a stainless steel bowl and spoon with either a hand auger or ponar sampler employed if deep water conditions necessitate their use. The slag samples will be screened by hand (in lieu of a mechanical shaker) in the field using conventional 12-in diameter round sieves commonly used for grain size determination (sieve analysis). Two sieves (¼-inch and 1-inch screen size), a pan, and a lid will be required. The wet samples will be allowed to gravity drain and will be screened through the sieves. The slag samples will consist of pieces of slag that pass through a 1 inch sieve but are retained by a ¼ inch sieve. This methodology should result in a sample that is similar to the typical size of slag observed in the Little Vermilion River during the physical characterization performed in October, 2007. Slag pieces of this grain size interval should be of sufficient size to be distinguishable from native materials by trained field personnel. Native materials will be manually separated from slag materials. Sieved materials that are not slag, such as pieces of brick, debris, or native material, will be removed from the sample. Each slag sample will be double bagged in a Ziploc® bag and shipped to the lab for leachability testing. Each sample must be of sufficient volume (3.5 Kg) to perform leachability tests using two different solutions, in triplicate. In addition, two slag samples from the Little Vermilion River (LRS-412 and LRS-413) must also be collected in sufficient volume to sieve the samples, separate the native material from the slag, and perform an SPLP extraction and an SEP on the sample for subsequent analysis of TAL metals (600 grams of slag is needed to perform these analyses). In addition, sufficient slag (unsieved and unsorted) will be collected for two samples (LRS-412 and LRS-413) in sufficient volume to perform an SPLP extraction for subsequent analysis of TAL metals.

2.4.2.3 Upstream River Samples

Approximately 25 liters of river water will be collected just upstream of the site and placed in plastic carboys for shipment in coolers to the laboratory. The river water will be utilized in the specialty leachability tests.

2.4.3 Sample Handling and Analysis

Proper field sampling documentation and field analytical and laboratory documentation helps to ensure sample authenticity and data integrity. Section 3.2 of this document describes the methods for assigning unique sample names. The unique sample name will be used on the sample containers, sample tags, and Chain-of-Custody Record. Procedures for sample shipping are described in SOP No. 410.

Specialized Leachability Testing

A specialized leachability test will be performed by Geosyntec personnel in Knoxville, Tennessee on each of the slag samples collected from the slag pile and from the river. Each of the six slag samples will be tested using two extraction liquids (SPLP and upstream river water) with three replicates each (for a total of 36 data points). This test is described in Attachment A to the QAPP Addendum No. 1. The test entails subjecting slag to realistic site leachability conditions, as opposed to solely relying on laboratory leachability tests, which involve sample homogenization. The slag will be screened through sieves in the field to attain similar sizes for testing purposes. The slag samples collected for leachability testing will contain slag pieces that pass through a 1-inch soil sieve and are retained by a ¼-inch sieve. The samples will be inspected visually and all pieces of rock or other materials that are not slag will be removed from the sample. The samples will be double bagged in Ziploc bags by Geosyntec field personnel and sent to Geosyntec's Knoxville office for leachability testing. Upon completion of the specialized leachability testing, the resulting liquid will be sent to CAS in Rochester, New York for analysis of 23 TAL metals using USEPA Methods 6010B/6020A/7470A/7471B), as presented in Table 1.

Conventional SPLP and SEP Testing

Conventional SPLP and SEP testing will be performed on three sieved and sorted slag samples (SLP-415, LRS-412, and LRS-413). Conventional SPLP testing will be performed on three unsieved (intact and unsorted) slag samples (SLP-415, LRS-412, and LRS-413). The SPLP analysis will be performed using USEPA Method 1312 by CAS in Rochester, New York and the SEP analysis will be performed using a laboratory-specific SOP by TestAmerica (formerly STL) in Knoxville, Tennessee.

The SPLP is used to evaluate the potential for leaching metals into ground and surface waters. This method was developed to provide a more realistic assessment of metal mobility under actual field conditions (e.g., what happens when it rains or snows) as compared to other conventional leaching procedures. The extraction fluid is intended to simulate precipitation.

SEP analyses are primarily focused towards a detailed evaluation of metals speciation, although they can be used for bioavailability assessments. SEP consists of six different extractions of metals from a soil or sediment sample. Each extractant is intended to liberate metals bound by a particular sorption mechanism; in general, the extractions become increasingly aggressive. After the full sequence, it is possible to estimate the relative importance of sorption mechanisms by comparing the relative recoveries of the six extraction steps. By understanding which of the six possible sorption mechanisms is currently occurring, one can dramatically improve the understanding of attenuation processes, seek *in situ* remedial options, and predict the geochemical effects of a given remedial action.

2.5 Biological Assessment of the Little Vermilion River

The biological assessment of the Little Vermilion River is comprised of three main scopes of work: (i) performing a fish and macroinvertebrate community assessment to evaluate the biological health of the river: (ii) calculating an index of biotic integrity; and (ii) analyzing biological tissue. These scopes of work are discussed in Section 2.5.1 through 2.5.3. Sampling of fish and macroinvertebrate communities will take place in the same general locations and at the same time as sediment sampling.

2.5.1 Biological Community Assessment

To evaluate the potential impacts of the site on the aquatic community of the Little Vermilion River, a biological community assessment will be conducted. Field studies targeting fish and benthic macroinvertebrates (aquatic insects and mollusks) will be conducted following established sampling/bioassessment protocols that will yield an indication of the Biotic Integrity of the aquatic community in the Little Vermilion River bordering the Site. The macroinvertebrate and mussel community assessment will discriminate biotic integrity for east and west halves of the river and holistically. The resulting information will support development of the Baseline Ecological Risk Assessment (BERA) for OU1. These field studies will be conducted in four community assessment reaches (CAR-001 through CAR-004), including one reference location (CAR-004), one location along the OU2 upland area (CAR-003), and two locations along OU1 upland areas (CAR-001 and CAR-002), as shown in Figure 1.

2.5.1.1 <u>Sample Locations and Frequency</u>

Aquatic community surveys of the Little Vermilion River will be conducted within a minimum 330 ft/100-meter (m) river reach at each of four locations (Figure 1):

- along the southern - central boundary of OU1 upstream of the 5th Street Bridge (CAR-001);
- along the northern - central boundary of OU1 (CAR-002);
- along the northern - central boundary of OU2 (CAR-003); and
- in the vicinity of Illinois Department of Natural Resources (IDNR) long-term monitoring station (DR- 03) located approximately one mile upstream of OU2 (CAR-004).

The precise location of each sample reach will be determined in the field based on an aquatic habitat assessment by experienced biologists. The objective of this assessment will be to select river reaches of comparable habitat to limit sample bias, as habitat characteristics are major factors that control the structure of aquatic communities. The habitat assessment will be conducted by qualified aquatic scientists using established IDNR (fish community), IEPA (macroinvertebrate community) guidance, as well as applicable USEPA guidance, and will include qualitative physical habitat and quantitative water quality parameters.

The sample reach located upstream of OU2 will serve as the reference reach to which the aquatic community structure determined at the three other sample river reaches will be compared. As such, it will be important that aquatic habitats in the sample river reaches along OU1 and OU2 are comparable to those found at the reference reach.

2.5.1.2 Fish Community Sampling

Fish community sampling at the four selected sample river reaches will be conducted in general accordance with IDNR Fisheries Stream Sampling Guidelines (Attachment A to the FSP Addendum No. 1) under authority of, or consistent with, a valid Illinois Scientific Collections Permit. The Federal and State of Illinois Department of Natural Resources will be consulted prior to fish collection regarding what should be done with the capture of invasive species. Sampling will be conducted under summer-early fall low-flow conditions. Sample reaches of at least 100-m length will be blocked at the upstream and downstream boundaries using blocknets with a maximum bar mesh opening of 0.25 inch (in). Based on an initial reconnaissance of the Little Vermilion River conducted in fall 2007, the steep gradient within the river gorge near the site results in generally fast-moving water with run and riffle complexes interspersed with pools that combine to provide a diversity of aquatic habitat. Most areas of the stream are wadeable, but large boulders and exposed-irregular bedrock substrates favor the use of backpack electrofishing over an electric seine. In those areas where the river is not wadeable, boat-mounted electrofishing will be used. Fish community sampling will be further supplemented using a common sense minnow seine in wadeable areas suitable for the technique.

Data collected during fish community sampling will be recorded in the log book including, at a minimum, the following information: Date, time and location of sampling and data collection during fish sample processing; investigators performing the task; type of gear used to complete the task; weather conditions during sampling and data collection; common name, length and weight of fish species processed; and any physical anomalies observed in species collected and sampled. Data regarding sample preservation and handling will be recorded for any specimens that are retained for further identification.

The use of multiple gear types will assure that all available habitats of each sample reach are sampled thoroughly and the fish community characterized in a representative manner. The selected sampling methods are described below.

Backpack Electrofishing

The backpack electrofishing crew with consist of at least two people; an experienced aquatic biologist and technician. One person will operate the backpack and the second person will net stunned fish and place them in a water-filled bucket. In most cases it is expected that a third person will also be available to assist with the netting and handling of stunned fish. Each member of the sampling crew will wear rubber gloves and either hip boots or chest waders (with waist belts affixed), as appropriate for the sample reach.

To minimize injury to fish, only pulsed direct-current (DC) power will be used for sampling. Backpack electrofishing will be conducted in an upstream direction to minimize turbidity from walking in the stream. The anode probe will be thrust into any undercut backs, under rocks, or woody debris with power off, and then drawn slowly back to the operator with power on to optimize the attractive galvanotaxic response of fish. Electrofishing "power-on" time will be recorded for each sample reach.

Boat Electrofishing

Given the steep terrain of the Little Vermilion River gorge and instream features at the sample reaches, a small aluminum jon boat and outboard motor will be used to facilitate access to non-wadeable areas of the sampling reaches. The boat electrofishing crew will consist of at least two people; an experienced aquatic biologist and technician. One person will operate the boat and DC electrofishing unit, and one person will net the stunned fish. A third person may also be available to assist as well.

Dipnets used to collect stunned fish will have insulated handles with a net mesh size of no more that 0.25 inches (in) (bar measure). Dip netters will wear rubber gloves when netting fish; and all boat occupants will wear U.S. Coast Guard-approved personal flotation devices (PFDs).

The boat electrofishing crew will sample all available non-wadeable habitats within the sample reach including shoreline and mid-channel (i.e., open water areas). Electrofishing "power-on" time will be recorded for each sample reach.

Seining

The seining crew with consist of at least three people; an experienced aquatic biologist and two technicians. The selected gear type will be a "common sense" minnow seine of 4 to 6 ft in height and 25 ft in length with a net mesh opening (bar) of no more than 0.25 inch. Two people will maneuver the seine using linear sweeps to collect fish in generally open areas and circular sweeps where debris or other obstructions prevent linear sweeps. A third person will kick the substrate in front of the seine to drive fish towards the net. Each member of the sampling crew will wear either hip boots or chest waders (with waist belts affixed), as appropriate for the sample reach.

Fish Sample Processing

Fish samples will be processed live on site. Specimens will be temporarily held in a live well, identified to species, enumerated, measured (total length to nearest millimeter), weighed, (to nearest gram), examined for visible health anomalies, and returned to site waters. Fish sample information will be transferred to an appropriate data sheet. Vouchers will be retained for any non-protected specimens that are difficult to identify under field conditions owing to their size. Those specimens will be preserved, labeled, and handled according to IDNR protocol. Some fish specimens will be retained for tissue analysis as presented later in this sampling plan.

2.5.1.3 Aquatic Macroinvertebrate Community Sampling

Aquatic (benthic) macroinvertebrate community sampling will be conducted at the four selected sample river reaches in general accordance with the IEPA established field collection protocols (Attachment B to the FSP Addendum No. 1). The IEPA protocol employs a quantitative 20-jab multi-habitat sampling method combined with a 300 organism subsample. Individual jabs with a standard long-handled D-frame dipnet (approximately 1 ft frame width) with 500 micron (µm) mesh netting will be conducted by distributing the jabs proportionally among the multiple habitats present. Furthermore, each of the four selected river reaches will be longitudinally divided into east and west halves of the Little Vermilion River. Separate aquatic habitat assessments will be performed to identify habitat types and the IEPA 20-jab method protocol will be applied to both the east and west halves of the river. Resultant macroinvertebrate community data can be comparatively evaluated within and among each sample transect.

Macroinvertebrate Sample Processing

Samples collected from the multiple habitats within a given sample reach will be composited into a single sample. Organisms in the composite samples will be preserved in the field with 10 percent formalin and shipped under chain-of-custody to Pennington & Associates, Inc., Cookeville, Tennessee for sorting and identification. To comport with the IEPA standardized protocol, lab personnel will be instructed to randomly subsample 300 organisms from the larger composite sample for identification to the lowest practical taxon.

Freshwater Mussels

The IEPA benthic macroinvertebrate protocol is targeted specifically to the community structure of aquatic insects as indicators of stream condition. Freshwater mussels are known to occur in the Little Vermilion River and their abundance and species richness can also be used as an indication of stream condition. Of potential interest for this study, freshwater mussels are known to be sensitive to metal pollutants.

The freshwater mussel community will be qualitatively surveyed for the presence/absence of mussels at each sample reach via timed searches of one hour or more conducted by two or more personnel. Each of the four selected river reaches will be longitudinally divided into east and west halves of the Little Vermilion River. As such, the community assessment will differentiate biotic integrity for east and west halves of the river and holistically. A consistent search time period and number of personnel involved will be determined in the field; however, searches will be no less than one-hour in length involving at least two survey personnel. Surveys will be conducted by hand picking and use of a viewing bucket in wadeable areas, and by snorkeling in non-wadeable areas. Live specimens and relic shells will be collected for processing.

The mussel surveys are designed to provide species presence/absence information and relative abundance for each sample reach. Information for sample reaches along OU1 and OU2 will be compared to similar information collected at the upstream.

Mussel Processing

Live mussels will be processed on site. Specimens will be temporarily held in a water-filled bucket or live well, identified to species (where possible), enumerated, examined for health anomalies, and returned to site waters. Sample information will be recorded on appropriate field forms. Vouchers will be retained for any non-protected specimens that are difficult to identify. Some freshwater mussel specimens will be retained for tissue analysis as presented later in this sampling plan.

2.5.2 Indices of Biotic Integrity

The IDNR and IEPA have developed protocols for determining the biological integrity of Illinois streams based on biological community data collected in the field. The IDNR has developed the fish community “Index of Biotic Integrity” or IBI; and IEPA has developed the Stream Condition Index or SCI that is based on macroinvertebrate community structure. Both indices are used by IEPA to help assess attainment of Aquatic Life Use in Illinois streams in the context of Clean Water Act compliance (i.e., Section 303(d) impairment determinations).

These indices both employ a "multi-metric" scoring approach that places a value on a specific metric's deviation from an expected value; the least the deviation, the greater the score for the metric. The metrics serve as useful indicators of the effect of human influences on the environment.

2.5.2.1 Fish Community IBI Scoring

The fish community data collected from each sample reach will be analyzed based on the ten metrics included in the IDNR Fish IBI, which include the following:

- Species Richness Metrics
  - Number of native fish species
  - Number of native sucker species (i.e., in the family Catostomidae)
  - Number of native sunfish species (i.e., in the family Centrachidae)
  - Number of native pollution/disturbance intolerant species
  - Number of minnow species (i.e., in the family Cyprinidae)
  - Number of native benthic insectivore species
- Trophic- or reproductive-structure metrics
  - Proportion of individuals of species that are specialist benthic invertivores
  - Proportion of individuals of species that are generalist feeders
  - Proportion of individuals of species that are specialist obligate coarse-mineral-substrate spawners and not "tolerant" (i.e., excludes creek chub, *Semotilus atromaculatus*, and white sucker, *Catostomus commersonii*)
- Tolerance metric
  - Proportion of tolerant species

Each of these fish metrics will be scored by comparing to eco-regional reference values developed by IDNR for least disturbed sites per IDNR IBI protocol[1]. The metric scores are then summed to provide the IBI score. The maximum IBI score attainable is 60, which indicates a fish community reflecting the best attainable condition. However, an IBI score of 40 or greater indicates that Aquatic Life Use is "fully supported".

While it is insightful to evaluate the Little Vermilion River fish community relative to those found in undisturbed streams in the established ecoregion, it is particularly important in the current study to comparatively evaluate the fish community of sample reaches along OU1 and OU2 to the sample reach located upstream and away from any influence of the M&H Zinc Company Superfund Site. This evaluation will be accomplished using established comparative analyses and statistical approaches.

2.5.2.2 <u>Macroinvertebrate Community SCI Scoring</u>

Like the fish IBI, the IEPA protocol for calculating the SCI is also based on a multi-metric approach. The macroinvertebrate community data collected from each Little Vermilion River sample reach will be analyzed based on the seven metrics included in the IEPA SCI, which include the following:

- <u>Species Richness Metrics</u>
  - Number of Coleoptera (aquatic beetles) taxa (species)
  - Number of native Ephemeroptera (mayflies) taxa
  - Total number of taxa
- <u>Percent Composition Metrics</u>
  - Proportion of individuals represented by EPT2 species
  - Proportion of individuals that feed as "scrapers"

[1] Current IDNR Fish IBI Protocol is provided in the document titled: "*Draft Manual for Calculating Index of Biotic Integrity Scores for Streams in Illinois*", dated August 2000. This document is excluded from the Appendices due to volume, but can be provided upon request.
[2] The presence of Ephemeroptera (mayflies), Plecoptera (stoneflies), and/or Tricopetera (caddisflies) are indicators of good water quality.

- Tolerance Metric
    - Number of pollution/disturbance intolerant taxa
    - Hilsenhoff Biotic Index

Unlike the fish IBI where metrics are scored based on comparison to eco-regional reference values, IEPA uses a standardized approach whereby the SCI metrics are scored based on their respective percent deviation from an established "best value" determined from field studies at least disturbed sites statewide[3]. The individual metric scores (percentages) are then averaged to obtain the final SCI score. As such, the maximum SCI score attainable is 100, which indicates a macroinvertebrate community reflecting "Exceptional" condition. An SCI score ranging from 49.3 to 69.8 reflects "Good" conditions.

The current study will also include comparison of macroinvertebrate community structure along OU1 and OU2 to that of the upstream Little Vermilion River reference location. In this case, the individual macroinvertebrate metric scores for the upstream reference location will be established as the Little Vermilion River "best value". The individual metrics for the sample reaches along OU1 and OU2 will then be scored based on their respective percent deviation from the Little Vermilion River-specific "best value". The individual metric scores (percentages) will then be averaged to obtain the final Little Vermilion River-comparative SCI score[4].

2.5.3 Collection of Biotic Tissue

In the conduct of fish and macroinvertebrate community sampling, selected species will be retained for biotic tissue analysis to support the ecological (BERA) and human health risk assessments. For the BERA, samples of preyfish and freshwater mussels will be collected for total body burden analysis. For the human health risk assessment, a sportfish will be selected. The biotic tissue samples will be collected from three community reaches (CAR-001, CAR-003, and CAR-004) to evaluate body burden. Biotic tissue samples will be analyzed for selected metals including arsenic, cadmium, copper, lead, mercury, silver, and zinc, as well as lipids.

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[3] IEPA is currently revising their Stream Condition Index protocols. The approach described in the FSP is based on information provided in the document: "*Illinois Benthic Macroinvertebrate Collection Method Comparison and Stream Condition Index Revision*" dated November 2004 (available upon request).

[4] A similar approach will be evaluated for application to the Little Vermilion River-specific fish IBI comparative analysis.

Five biotic tissue samples will be collected from each of three established sample reaches; the most downstream positioned OU1 sample reach, the sample reach in the vicinity of OU2, and the upstream reference location. Target species will be subject to availability, but based on review of historical data are anticipated to be:

- <u>Preyfish Species</u>
  - Hornyhead chub, *Nocomis biguttatus*
  - Spotfin shiner, *Cyprinella spiloptera*
  - Central stoneroller, *Campostoma anomalum* (alternate)
  - Bluntnose minnow, *Pimephales notatus* (alternate)
- <u>Sportfish/Predator Species (a whole body and a filet sample will be collected as two separate samples)</u>
  - Smallmouth bass, *Micropterus dolomieu*
  - Largemouth bass, *M. salmoides* (alternate)
- <u>Freshwater Mussel Species (mussels will be collected from the eastern and western halves of the river as two separate samples)</u>
  - Unknown at this time; the most abundant, non-protected species will be selected in the field.

One prey fish species, one freshwater mussel species and one sportfish species will be collected for biotic tissue analysis from the three established sample reaches. Every effort will be made to retain the same species across sample reaches.

It is anticipated that from 20 to 30 individuals of the smaller preyfish; 20 to 30 mussels; and five to six sportfish individuals will be needed to comprise an adequate sample mass for analysis (i.e., the samples will be composited by species). Preyfish and freshwater mussel composites will be whole-body samples exclusively; a total of nine composite samples. Two sportfish composite samples will be prepared for each of the three sample reaches; a whole-body composite sample and a boneless, skinless fillet composite sample; a total of six sportfish species composite samples. A grand total of 15 composite biotic tissue samples will be collected.

Species representing each whole-body composite sample will be measured to the nearest millimeter and weighed to the nearest gram. Prey and sportfish species whole-body composite samples will be put into labeled Ziploc® bags and placed on ice in the field prior to freezing for shipment to the analytical laboratory under appropriate chain-of-custody. Sportfish species to be processed for fillets will likewise be placed in labeled Ziploc® bags and preserved with ice in the field prior to freezing for shipment to the analytical laboratory, where lab technicians will prepare the boneless, skinless fillets for analysis.

Freshwater mussels will be composited whole and preserved in the field on ice. These samples will be transported from the field in coolers to a controlled environment where the valves will be separated and the internal organs and adductor muscles removed and composited in labeled Ziploc® bags prior to freezing and shipping to the analytical laboratory under appropriate chain-of-custody.

Composited biotic tissue samples will be analyzed for the metals arsenic, cadmium copper, lead, mercury, silver, and zinc using USEPA Methods 6010B/6020A/7471A. These metals were selected primarily based on the results of the Little Vermilion River sampling event performed during the Phase 1 investigation. Arsenic, cadmium, copper, lead, silver, and zinc were measured at levels above USEPA Region 5 Ecological Screening Levels at one or more sediment or surface water locations. Mercury was added to the list for low level analysis due to USEPA's concerns about the presence of mercury and also because mercury has been detected in site media during previous investigations. Analysis of lipids will also be conducted using a CAS laboratory-specific SOP, as referenced in the QAPP Addendum. Analyte concentrations in biotic tissue will be reported based on wet weight of the sample.

Data collected during tissue collection will be recorded in the log book including, at a minimum, the following information: date, time and location of sampling; investigators performing sampling; type of gear used to complete the task when applicable; weather conditions during sampling; sample processing and preservation when applicable; common name, length and weight of species sampled; and any physical anomalies observed in sample specimens.

2.6 Field Quality Assurance /Quality Control Samples

Quality Assurance/Quality Control (QA/QC) samples are typically collected in the field and submitted to the laboratory along with other environmental samples to evaluate field and laboratory precision and accuracy. Evaluation of QA/QC sample results allows for the quality of the data to be assessed as part of the overall project QA.

The six types of QA/QC samples are as follows:

- trip blanks;
- equipment rinsate blanks;
- field blanks;
- filter blanks;
- duplicates; and
- matrix spike/matrix spike duplicates (MS/MSDs).

Trip blank, equipment rinsate blank, filter blank, and field blank samples are used to assess field conditions during sample collection and transport. Duplicates and MS/MSD samples are replicate samples used to help assess laboratory precision and accuracy. Section 3.2 describes the methods for assigning unique sample names. The unique sample name will be used on the sample containers, sample tags, and Chain-of-Custody Record. Samples will be placed in laboratory-supplied containers and preserved in accordance with the analytical requirements summarized in Table 3. One temperature blank will also be included with every shipping container from the laboratory to ensure that the samples arrive at acceptable temperatures.

The required frequency of QA/QC samples is summarized in Table 4.

2.6.1 Trip Blanks

Trip blanks are filled with reagent grade water at the laboratory, shipped to the Site with the empty sample containers, and returned to the laboratory with the filled sample containers. Trip blanks are used to determine if VOC samples have been cross-contaminated during shipping and handling. No trip blanks are anticipated for the Phase 2 investigation as no VOC analyses are proposed.

2.6.2 Equipment Rinsate Blanks

Equipment rinsate blanks will be collected following decontamination of sampling equipment (e.g., bowls, spoons, hand augers, knives). One equipment rinsate sample will be collected for every 20 samples submitted to the laboratory with a minimum of one equipment rinsate sample collected per sampling crew per day. Following decontamination of the equipment, deionized water will be poured over selected sampling equipment and collected for laboratory analysis. The equipment rinsate samples will be analyzed using the same methods used for field samples that day.

2.6.3 Field Blanks

Field blanks are samples of source water used for decontamination. One field blank sample will be collected for each source of water used for decontamination. Field blanks will be analyzed for metals (no VOCs are proposed during the Phase 2 investigation).

2.6.4 Duplicate Samples

Duplicate samples are samples of selected solid, groundwater, surface water, and sediment sample locations that are split samples collected in the field. Duplicate samples will be collected at a frequency of one sample for every 20 investigative samples submitted for laboratory analysis. Duplicate samples are collected after sample homogenization to evaluate the effectiveness of the homogenization protocol. An important exception to this is with VOCs; VOC duplicate aliquots are sampled directly from their source without homogenization to avoid VOC loss due to volatilization.

2.6.5 Matrix Spike/Matrix Spike Duplicate Samples

MS/MSD samples are replicate samples that are spiked with a known concentration of Chemicals of Potential Concern (COPCs) which are then measured as they would be for field samples; the results are used to determine precision and accuracy. One MS/MSD sample will be collected for every 20 investigative samples submitted for laboratory analysis. The volume of sample collected at each of the locations where MS/MSD samples will be obtained is triple the routine volume: the first aliquot serves as the field sample, the second aliquot as the MS, and the third as the MSD. An exception is with solid/sediment matrix samples for metals; in this case, only double sample volume is required.

3. DOCUMENTATION, SAMPLE PACKING, AND SHIPPING

3.1 Field Documentation

Field visits and sample collection programs are documented using a combination of field log books and specific field log forms. These two methods have their advantages and disadvantages, as follows:

- Field log books have the advantage of maintaining work chronology. Since all pages and lines are used in sequence without any skips, it is possible to reconstruct the sequence of work in the event that any quality issues or other incidents arise. One log book can be used to document several weeks' worth of work in sequence depending upon the nature of the work. In addition, since log books lack structure, they provide flexibility in that they can be used to document nearly any site work; however, the lack of structure in log books is a disadvantage for record-intensive work, such as groundwater sampling, because the lack of entry boxes for field parameters discourages consistent data collection.

- Conversely, field forms have the advantage of customization (e.g., a groundwater sampling form can be designed in detail to remind the field team member to record a list of specific readings). Field forms are valuable for large sampling events in which consistency in the method of recording observations is desired. They have the disadvantage of lacking weatherproofing or any degree of chronological sequence. They are also not as portable or durable as log books.

A log book will be in use for all visits to the Site, ranging from brief site walks to major, multi-week characterization programs. If the work is short in duration (e.g., less than one day) and irregular or *ad hoc* in nature (i.e., a task that is not captured by a standard field form), then all of the work shall be documented in the log book. Conversely, if the site visit is longer in duration and more repetitive (e.g., a major groundwater or solid sampling event), corresponding field forms will be used for documentation of each sample, whereas the log book will be used to document a summary of the day's activities and non-repetitive tasks, including the following:

- time of arrival and departure from the Site, including lunch breaks;
- names of field team members;
- time of arrival and departure of subcontractors;
- the nature of the daily health and safety tailgate meeting, with signatures of all participants;
- instrument calibration;
- supply deliveries;
- weather;
- interaction with agency or client personnel;
- incident occurrence and management; and
- any other irregular or *ad hoc* activities.

As such, the log book(s) will provide a comprehensive overview of all site activities throughout the RI/FS; the level of detail of documentation within each log book entry will depend upon the duration of an individual visit and the applicability of field forms to the tasks performed.

3.1.1 Details of Log Book Use

Sampling personnel will use a bound field log book with moisture-resistant pages to record pertinent field information with waterproof ink. The log book will identify the project name, project number, and geographic location of the site; it will also indicate the name and mobile telephone number of the Field Manager in the event that the log book is lost and recovered. Daily field activities and sampling information will be entered in the log book on serially-numbered pages. At the end of each day's entries, sample collection personnel shall sign and date the entry. Corrections will be made to entries with initialed and dated line-out deletions. A diagonal line will be drawn across the remaining blank space of the last page of each day's entry. All log book lines will be used in sequence, and no blank lines shall remain at the end of the day. All observations will be recorded in sequence.

Multiple log books will be required over the course of the RI/FS. It is desirable to have a continuous sequence of log books throughout the course of the project, with one log book in use at any one time. Upon completion of a log book, the timeframe covered will be clearly indicated on the front cover and spine by noting the date range of work and investigative phase name. In some cases, however, the presence of multiple field teams may require the use of two log books in parallel. In these cases, the Field Manager shall maintain the primary log book. The secondary log book shall be clearly identified as such and shall make reference to the primary log book on or inside its front cover. It shall only be used to record observations made away from the Field Manager.

3.1.2 Field Forms

As discussed in Section 3.1, field forms shall be used for specific field sampling tasks of a routine and repetitive nature, such as solid sampling, well purging, or well installation. Field forms have the advantage of prompting the user for detailed data documentation in a consistent format. Field forms are provided as Attachment D to the QAPP.

The protocol for form completion will be similar to those of log books:

- one form will be filled out per sample;
- corrections shall be made through single-line strikeout with initial and date; and
- tables within forms (e.g., field parameters during well purging) shall be filled out with each line in sequence; no lines will be skipped, and unused lines at the end of sample collection shall be crossed out, initialed, and dated.

3.2 Sample Nomenclature

3.2.1 Field Sample Nomenclature

The sample identification scheme for field sample collection will utilize a three-letter project identification code followed by a sample type code, location code, and depth or date details. The general form is as follows:

OU1-aa-bbbbbb-yymm(dd)(-D1-D2), where identification components are described below.

OU1 will be used for the OU1 RI to differentiate samples and locations from those of the OU2 RI/FS.

"aa" is the matrix code or sample type code, which will correspond to the sample type as follows:

- AA: ambient air;
- DC: drill cuttings for disposal;
- DW: decontamination water;
- GW: groundwater sample;
- IW: interstitial water sample;
- MI: macroinvertebrate sample;
- MT: mussel tissue sample;
- PT: preyfish tissue sample;
- PW: purge water for disposal;
- SB: sportfish whole body sample;
- SE: sediment samples;
- SF: sportfish filet tissue sample;
- SS: solid matrix samples (e.g., soil, slag, sinter, etc.);
- SW: surface-water samples.

"bbbbbb" is the location code, which will follow the sample type code and will consist of up to six characters that indicate the sample location. Hyphens will be omitted. For groundwater samples, the location code will be the monitoring well number. Solid, sediment, and surface-water samples will use the location identifications (IDs) shown on sample location figures. For some samples, a differentiator in parentheses will follow the location code as follows:

- (A): placeholder for one of the letters defined below;
- (C): collected from the central portion of the reach of the river;
- (E): collected from the eastern reach of the river;
- (S): sieved sample greater than ¼ inch diameter, but smaller than 1 inch diameter – refers to slag samples;
- (T): total sample, intact (not sieved) – refers to slag samples or slag mixed with natural sediments; and
- (W): collected from the western reach of the river.

(-yymm) is only used (without parentheses) for samples where resampling at a given location may occur. If a sample location is resampled in the same month, the sample ID will include the day of the month as well (-yymmdd). Note that any single digit months or days will include a leading “0”.

(-D1-D2) is only used (without parentheses) for solid samples, because depth is a critical sample differentiator. Examples of sample identification numbers include:

- OU1-GW-P1-0705, for OU1, groundwater sample from monitoring well P-1 in May 2007;
- OU1-SS-SB301-2-4, for OU1, solid sample from DPT Soil Boring 301 at a depth of 2 to 4 ft BLS;
- OU1-SW-LVR211-0705, for OU1, surface-water sample from Little Vermilion River Location 211 in May 2007;
- OU1-SE-LVR211-0705, for OU1, sediment sample from Little Vermilion River Location 211 in May 2007; and
- OU1-AA-SB301N-070525, for OU1, ambient air sample from the north side of SB-301 workzone on 25 May 2007 (date characteristics indicate that location was previously sampled in the same month).

3.2.2 Quality Assurance/Quality Control Sample Nomenclature

QA/QC samples will have a blind naming system to ensure that they are treated the same way as field samples are treated. For all QA/QC samples, use the following fictitious locations, each of which indicates a type of QA/QC sample. If multiple QA/QC samples are collected on a given day, append A, B, C, etc. in sequence to the fictitious location name.

The fictitious locations are as follow:

- for equipment blanks, use MW-401;
- for trip blanks, use MW-402;
- for filter blanks, use MW-403;
- for water matrix duplicates, use MW-404, and for solid matrix duplicates, use SB-406; and
- for field blanks, use MW-405.

For blank samples, the matrix identifier ("aa" in the formula above) will be "SW" in order to have the appearance of a field sample. Sample IDs for duplicate samples will carry the matrix of the parent sample.

Because the sample ID gives no parent sample information for field duplicates, it is imperative that field documentation record this information so that parent/duplicate data pairings are available after analytical data have been received. For MS/MSDs, use the same sample ID as the parent sample and indicate "MS/MSD" in the comment field on the Chain-of-Custody Record.

3.3 Sample Packing and Shipping – Field Procedures

3.3.1 Hold Times

The first step in proper sample handling and custody is observance of analytical holding times, which can vary from 24 hours to one year depending upon media type and analytical method(s) selected for the samples. Knowledge of required holding times will have a direct impact on scheduling of sample collection, packing, and shipping activities. The sample container, volume, preservation, and holding times applicable to each analytical method are shown in Table 3.

3.3.2 Sample Custody

Sample collection and sample custody procedures are designed so that field custody of samples is maintained and documented. These procedures provide identification and documentation of the sampling event and the sample chain-of-custody from shipment of sample bottleware, through sample collection, to receipt of the sample by the subcontracted laboratory. When used in conjunction with the laboratory's custody procedures and the sample bottleware documentation, these data establish full legal custody and allow complete tracking of a sample from preparation and receipt of sample bottleware to sample collection, preservation, and shipping through laboratory receipt, sample analysis, and data validation. The chain-of-custody is defined as the sequence of persons who have the item in custody.

Field custody procedures are described below. Sample collection procedures concerning sample identification and documentation, field log book, sample containers, sample packing, and sample shipping are described.

The persons responsible for sample custody, and a brief description of their duties, are as follows:

- **Laboratory Sample Custodian or Commercial Supplier:** Verifies that the bottleware is certified clean; arranges for bottleware shipment to field sampling personnel or the contractor's equipment shop.

- **Field Staff:** Receives sample bottleware from laboratory, inspects bottleware for physical integrity; retains shipping invoice or packing list from shipping courier as documentation of transfer of bottleware; collects and preserves samples; retains bottleware and samples under custody until sample shipment; relinquishes samples to shipping courier or to lab representative.

- **Laboratory Project Manager:** Verifies reported laboratory analyses to the sample Chain-of-Custody Record; assures that chain-of-custody documentation is incorporated into the project file.

A sample or other physical evidence is in custody if it is:

- in the field investigator's, transferee's, or lab technician's actual possession; or

- in the field investigator's, transferee's, or lab technician's view, after being in his/her physical possession; or

- in the field investigator's, transferee's, or lab technician's physical possession and then he/she secured it to prevent tampering; or
- placed in a designated secure area.

3.3.3 Chain-of-Custody Record

The field Chain-of-Custody Record is used to record the custody of all samples or other physical evidence collected and maintained. This form shall not be used to document the collection of split or duplicate samples. The Chain-of-Custody Record also serves as a sample logging mechanism for the analytical laboratories' sample custodian.

The following information must be supplied in the indicated spaces in detail to complete the field Chain-of-Custody Record:

- project-specific information, including the project number and project name;
- signatures of all samplers and/or the sampling team leader in the designated signature block;
- sampling station number, date, and time of sample collection, grab or composite sample designation, and sample preservation type included on each line (each line shall contain only those samples collected at a specific location);
- sampling team leader's name recorded in the right or left margin of the Chain-of-Custody Record when samples collected by more than one sampling team are included on the same form;
- total number of sample containers listed in the indicated space for each sample and the total number of individual containers for each type of analysis under the indicated media or miscellaneous columns (note that it is impossible to have more than one media type per sample);
- sample volume (for air samples only);
- documentation of the transfer of samples listed on the Chain-of-Custody Record by the

field investigator and subsequent transferee(s) in the spaces provided at the bottom of the form (both the person relinquishing the samples and the person receiving them must sign the form; provide the date and time that this occurred in the proper space on the form; and usually, the last person receiving the samples or evidence should be a laboratory sample custodian); and

- air bill numbers or registered or certified mail serial numbers recorded in the remarks column at the bottom of the form.

The Chain-of-Custody Record is a serialized document. Once the Chain-of-Custody Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated upon its inclusion of all of the above information in a legible format. Examples of Chain-of-Custody Records for each laboratory described in this document were provided as Attachment B to the QAPP and are not included herein.

3.3.4 Sample Packing and Shipping

Sediment, Surface Water, Interstitial Water, and Slag Samples

Samples are packed for shipping in waterproof ice chests and coolers. Depending upon container type, the sample containers may be individually sealed in Ziploc® or other similar plastic bags, prior to packing them in the cooler with bubble wrap or Styrofoam packing. Wet ice will be double-bagged in plastic bags (to inhibit cross contamination of samples by melt water) and placed with the samples in the cooler to maintain the samples at a temperature of 4 +/- 2 degrees Celsius during shipping. Note that samples for analysis of metals in particulates do not require preservation; they can be sent at ambient temperature.

The Chain-of-Custody Record that identifies the samples is signed as "relinquished" by the principal sampler or responsible party. This Chain-of-Custody Record is sealed in a waterproof plastic bag and is placed inside the cooler, typically by taping the bag to the inside lid of the cooler.

Following packing, the cooler lid is sealed with packing tape. A custody seal is signed, dated, and affixed from the cooler lid to the cooler body, and is additionally covered with clear tape. This ensures that tampering with the cooler contents will be immediately evident.

The sample coolers are typically shipped by overnight express courier to the laboratory. A copy of the shipping invoice is retained by the Field Manager and becomes part of the sample custody documentation.

Biological Samples

Samples will be packed for shipping in ice chests and coolers. Individual composites will be sealed in Ziploc® or other similar plastic bags prior to packing. Dry ice will be covered and insulated with newspaper to help maintain the samples in a frozen condition during shipping.

Chain of Custody Records will be sealed in waterproof plastic bags and taped inside the cooler lids.

After packing, cooler lids will be sealed with strapping tape. Custody seals will be signed, dated, and affixed from the cooler lid to the cooler body, and covered with clear tape. This will ensure that any tampering with the cooler contents would be immediately evident to sample custodians on the receiving end of shipment.

Sample coolers will be shipped by overnight express courier to the analytical laboratory. A copy of the bill of lading will be retained by the QA Officer and become part of the sample custody documentation.

4. DECONTAMINATION

Decontamination of sampling equipment will take place either at sampling locations or in a centralized area. Decontamination of drilling equipment and tools will be conducted in a centralized area to improve management of decontamination liquids. Prior to arrival on-site, all downhole drilling equipment will be pressure-washed. Equipment used for drilling and sampling will be decontaminated prior to each use and in accordance with the cleaning procedures presented in Section 4 of the FSP and are not repeated herein.

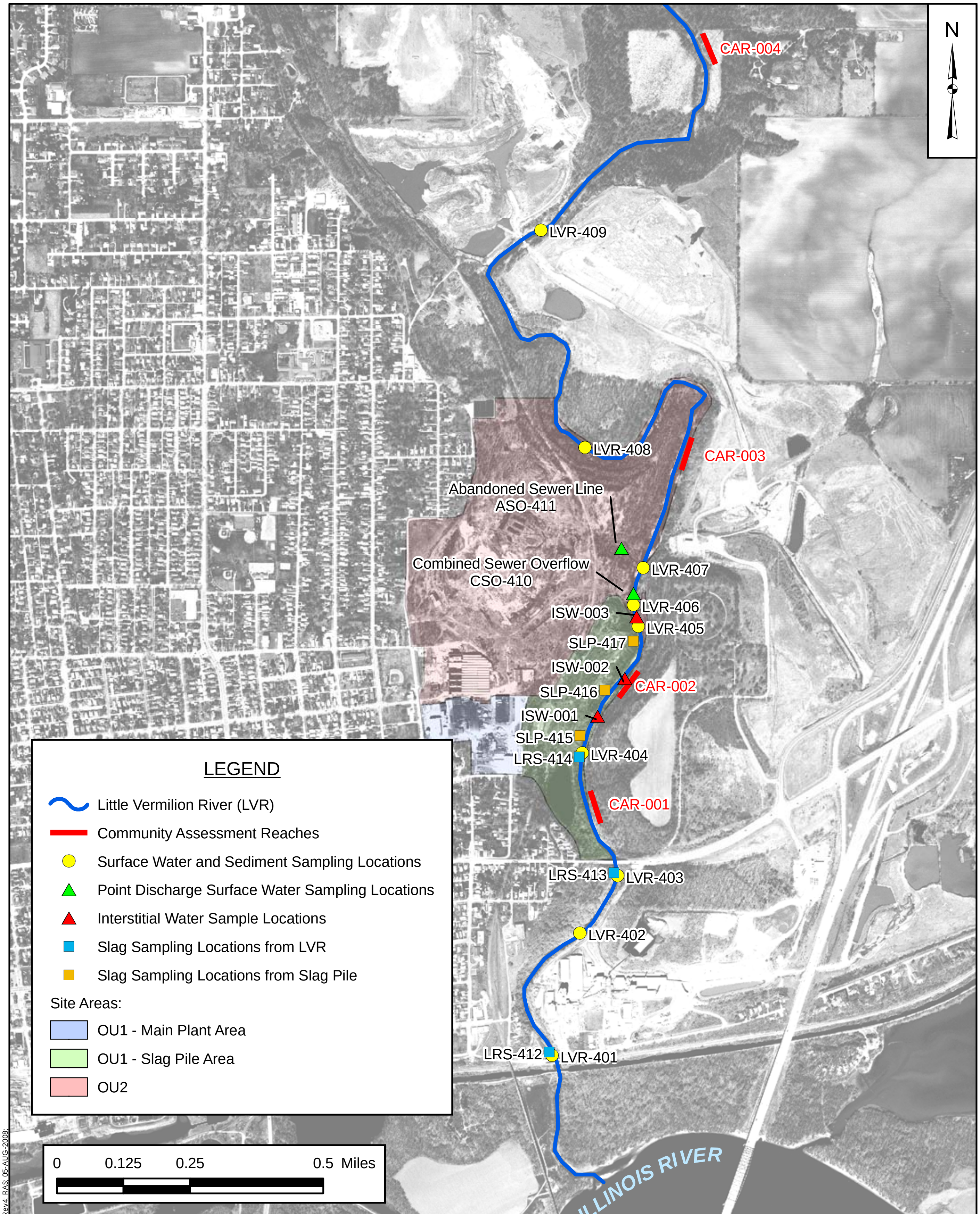
5. MANAGEMENT OF INVESTIGATION-DERIVED WASTES

Solid and liquid waste will be tested for the Resource Conservation and Recovery Act (RCRA) Toxicity Characteristic Leaching Procedure (TCLP) waste profiling followed by disposal to RCRA Subtitle D or C facilities as needed. TCLP analyses will be performed per the requirements of the receiving facility. Waste will be managed according to USEPA's 1992 document "Guide to Management of Investigation-Derived Wastes". Wastes generated and disposed of will meet all of the State of Illinois regulations regarding storage and disposal, including transportation requirements including Illinois Administration Codes: Parts 720, 721, 722, 723, 724, 725, and 728. Wastes generated by investigations may need to be regarded as special wastes unless characterization testing reveals otherwise. Procedures for managing investigation-derived waste are provided in Chapter 5 of the original FSP and are not repeated herein.

6. SCHEDULE

A schedule for RI/FS tasks is discussed in the Work Plan.

FIGURE



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CARUS

16-APR-2009

Phase 2 Little Vermilion River Characterization

Matthiessen and Hegeler Zinc Company Site, OU1
LaSalle, Illinois

Figure 1

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TABLES

Table 1. Sample IDs, Locations, Depths, and Analyses for Samples
Phase 2 - Remedial Investigation/Feasibility Study
Matthiessen and Hegeler Zinc Company Site, Operable Unit 1
LaSalle, Illinois

Sample ID	Matrix	Location	TAL Metals[1]	SPLP	SEP	Selected Metals for Tissue Analysis [2]	Lipids	Hardness	Field Parameters					
									Temperature	Conductivity	DO	Turbidity	pH	ORP
OU1-SE-LVR401(A)-yymm	Sediment	LVR-401	X											
OU1-SW-LVR401(A)-yymm	Surface Water	LVR-401	X					X	X	X	X	X	X	X
OU1-SE-LVR402(A)-yymm	Sediment	LVR-402	X											
OU1-SW-LVR402(A)-yymm	Surface Water	LVR-402	X					X	X	X	X	X	X	X
OU1-SE-LVR403(A)-yymm	Sediment	LVR-403	X											
OU1-SW-LVR403(A)-yymm	Surface Water	LVR-403	X					X	X	X	X	X	X	X
OU1-SE-LVR404(A)-yymm	Sediment	LVR-404	X											
OU1-SW-LVR404(A)-yymm	Surface Water	LVR-404	X					X	X	X	X	X	X	X
OU1-SE-LVR405(A)-yymm	Sediment	LVR-405	X											
OU1-SW-LVR405(A)-yymm	Surface water	LVR-405	X					X	X	X	X	X	X	X
OU1-SE-LVR406-yymm	Sediment	LVR-406	X											
OU1-SW-CSO410-yymmdd	Surface water	CSO-410	X					X	X	X	X	X	X	X
OU1-SE-LVR407-yymm	Sediment	LVR-407	X											
OU1-SW-ASO411-yymmdd	Surface water	ASO-411	X					X	X	X	X	X	X	X
OU1-SE-LVR408-yymm	Sediment	LVR-408	X											
OU1-SW-LVR408-yymm	Surface water	LVR-408	X					X	X	X	X	X	X	X
OU1-SE-LVR409-yymm	Sediment	LVR-409	X											
OU1-SW-LVR409-yymm	Surface water	LVR-409	X					X	X	X	X	X	X	X
OU1-MT-CAR001(A)-yymm	Mussel Tissue	CAR-001				X	X							
OU1-PT-CAR001-yymm	Preyfish Tissue	CAR-001				X	X							
OU1-SF-CAR001-yymm	Sportfish Filet Tissue	CAR-001				X	X							
OU1-SB-CAR001-yymm	Sportfish Whole Body Tissue	CAR-001				X	X							
OU1-MT-CAR003(A)-yymm	Mussel Tissue	CAR-003				X	X							
OU1-PT-CAR003-yymm	Preyfish Tissue	CAR-003				X	X							
OU1-SF-CAR003-yymm	Sportfish Filet Tissue	CAR-003				X	X							
OU1-SB-CAR003-yymm	Sportfish Whole Body Tissue	CAR-003				X	X							
OU1-MT-CAR004(A)-yymm	Mussel Tissue	CAR-004				X	X							
OU1-PT-CAR004-yymm	Preyfish Tissue	CAR-004				X	X							
OU1-SF-CAR004-yymm	Sportfish Filet Tissue	CAR-004				X	X							
OU1-SB-CAR004-yymm	Sportfish Whole Body Tissue	CAR-004				X	X							
OU1-IW-ISW001-yymm	Interstitial Water	ISW-001	X					X	X	X	X	X	X	X
OU1-IW-ISW002-yymm	Interstitial Water	ISW-002	X					X	X	X	X	X	X	X
OU1-IW-ISW003-yymm	Interstitial Water	ISW-003	X					X	X	X	X	X	X	X
OU1-SS-LRS412(S)-yymm[3]	LVR Slag	LRS-412	X	X	X									
OU1-SS-LRS413(S)-yymm[3]	LVR Slag	LRS-413	X	X	X									
OU1-SS-LRS414(S)-yymm[3]	LVR Slag	LRS-414	X											
OU1-SS-SLP415(S)-yymm[3]	Slag from Slag Pile	SLP-415	X	X	X									
OU1-SS-SLP416(S)-yymm[3]	Slag from Slag Pile	SLP-416	X											
OU1-SS-SLP417(S)-yymm[3]	Slag from Slag Pile	SLP-417	X											
OU1-SS-LRS412(T)-yymm	LVR Slag	LRS412	X	X										
OU1-SS-LRS413(T)-yymm	LVR Slag	LRS413	X	X										
OU1-SS-SLP415(T)-yymm	Slag from Slag Pile	SLP415	X	X										
OU1-MI-CAR001(E)-yymm[4]	Macroinvertebrate	CAR-001												
OU1-MI-CAR001(W)-yymm[4]	Macroinvertebrate	CAR-001												
OU1-MI-CAR002(E)-yymm[4]	Macroinvertebrate	CAR-002												
OU1-MI-CAR002(W)-yymm[4]	Macroinvertebrate	CAR-002												
OU1-MI-CAR003(E)-yymm[4]	Macroinvertebrate	CAR-003												
OU1-MI-CAR003(W)-yymm[4]	Macroinvertebrate	CAR-003												
OU1-MI-CAR004(E)-yymm[4]	Macroinvertebrate	CAR-004												
OU1-MI-CAR004(W)-yymm[4]	Macroinvertebrate	CAR-004												

Footnotes
1 - List of metals for low level analysis for sediment, surface water, and interstitial water samples includes arsenic, cadmium, copper, lead, mercury, silver, and zinc.
2 - Biotic tissue samples will be analyzed for selected metals including arsenic, cadmium, copper, lead, mercury, silver, and zinc.
3 - Each of these slag samples will be tested using two solutions of differing pH (one upstream river water sample and one SPLP liquid).
4 - Macroinvertebarte samples will be collected using the 20-jab mulit-habitat method combined with a 300 organism subsample and will be preserved in the field with 10 percent formalin and shipped to the lab for sorting and identification.
Notes
1. TAL: Total Analyte List
2. SPLP: Synthetic Precipitation Leaching Procedure
3. SEP: Sequential Extraction Procedure
4. DO: Dissolved Oxygen
5. ORP: Oxygen Reduction Potential

Table 2
Sample Location Rationale
Phase 2 - Remedial Investigation/Feasibility Study
Matthiessen and Hegeler Zinc Company Site, Operable Unit 1
LaSalle, Illinois

Location	Matrix	Coincident Location	Rationale
OU1-SE-LVR401(X)-yymm	Sediment	LVR-401	First depositional area upstream of the I&M Canal
OU1-SW-LVR401(X)-yymm	Surface water	LVR-401	
OU1-SE-LVR402(X)-yymm	Sediment	LVR-402	Last accessible depositional area upstream of the cement plant
OU1-SW-LVR402(X)-yymm	Surface water	LVR-402	
OU1-SE-LVR403(X)-yymm	Sediment	LVR-403	Depositional area downstream of the Fifth Street Bridge
OU1-SW-LVR403(X)-yymm	Surface water	LVR-403	
OU1-SE-LVR404(X)-yymm	Sediment	LVR-404	Within depositional area located along the southern portion of slag pile area
OU1-SW-LVR404(X)-yymm	Surface water	LVR-404	
OU1-SE-LVR405(X)-yymm	Sediment	LVR-405	
OU1-SW-LVR405(X)-yymm	Surface water	LVR-405	
OU1-SE-LVR406-yymm	Sediment	LVR-406	Depositional area downstream from where the CSO discharges into the LVR
OU1-SW-CSO410-yymm	Surface water	CSO-410	CSO discharge to LVR at point of discharge
OU1-SE-LVR407-yymm	Sediment	LVR-407	Depositional area where the creek flowing from the abandoned sewer discharges into the LVR
OU1-SW-ASO411-yymm	Surface water	ASO-411	Abandoned sewer discharge to LVR (collected at the point of discharge from the outlet tunnel into the creek)
OU1-SE-LVR408-yymm	Sediment	LVR-408	Upstream of the dam to avoid potential effects from the dam
OU1-SW-LVR408-yymm	Surface water	LVR-408	
OU1-SE-LVR409-yymm	Sediment	LVR-409	Upstream of OU2 and the slag pile area (background)
OU1-SW-LVR409-yymm	Surface water	LVR-409	
OU1-MT-CAR001(A)-yymm	Mussel Tissue	CAR-001	Biota samples for tissue analysis collected from Community Assessment Reach 1 near the southern portion of the site
OU1-PT-CAR001-yymm	Preyfish Tissue	CAR-001	
OU1-SF-CAR001-yymm	Sportfish Filet Tissue	CAR-001	
OU1-SB-CAR001-yymm	Sportfish Whole Body	CAR-001	
OU1-MT-CAR003(A)-yymm	Mussel Tissue	CAR-003	Biota samples for tissue analyis collected from Community Assessment Reach 3 north of the slag pile adjacent to OU2
OU1-PT-CAR003-yymm	Preyfish Tissue	CAR-003	
OU1-SF-CAR003-yymm	Sportfish Filet Tissue	CAR-003	
OU1-SB-CAR003-yymm	Sportfish Whole Body	CAR-003	
OU1-MT-CAR004(A)-yymm	Mussel Tissue	CAR-004	Biota samples for tissue analysis collected from Community Assessment Reach 4 upgradient of site (reference location)
OU1-PT-CAR004-yymm	Preyfish Tissue	CAR-004	
OU1-SF-CAR004-yymm	Sportfish Filet Tissue	CAR-004	
OU1-SB-CAR004-yymm	Sportfish Whole Body	CAR-004	
OU1-GW-ISW001-yymm	Interstitial Water	ISW-001	Interstitial water sample taken between LVR and slag pile area
OU1-GW-ISW002-yymm	Interstitial Water	ISW-002	
OU1-GW-ISW003-yymm	Interstitial Water	ISW-003	
OU1-SS-LRS412-yymm	LVR Slag	LRS-412	Characterization of slag present in depositional area within LVR
OU1-WS-LRS412-yymm	LVR Slag	LRS-412	
OU1-SS-LRS413-yymm	LVR Slag	LRS-413	
OU1-WS-LRS413-yymm	LVR Slag	LRS-413	
OU1-SS-LRS414-yymm	LVR Slag	LRS-414	
OU1-SS-SLP415-yymm	Slag from Slag Pile	SLP-415	Characterization of exposed slag from slag pile
OU1-WS-SLP415-yymm	Slag from Slag Pile	SLP-415	
OU1-SS-SLP416-yymm	Slag from Slag Pile	SLP-416	
OU1-SS-SLP417-yymm	Slag from Slag Pile	SLP-417	
OU1-MI-CAR001(E)-yymm[4]	Macroinvertebrate	CAR-001	Physical characterization of macroinvertebrates from

Table 2
Sample Location Rationale
Phase 2 - Remedial Investigation/Feasibility Study
Matthiessen and Hegeler Zinc Company Site, Operable Unit 1
LaSalle, Illinois

OU1-MI-CAR001(W)-yymm[4]	Macroinvertebrate	CAR-001	Community Assessment Reach 1
OU1-MI-CAR002(E)-yymm[4]	Macroinvertebrate	CAR-002	Physical characterization of macroinvertebrates from Community Assessment Reach 2
OU1-MI-CAR002(W)-yymm[4]	Macroinvertebrate	CAR-002	
OU1-MI-CAR003(E)-yymm[4]	Macroinvertebrate	CAR-003	Physical characterization of macroinvertebrates from Community Assessment Reach 3
OU1-MI-CAR003(W)-yymm[4]	Macroinvertebrate	CAR-003	
OU1-MI-CAR004(E)-yymm[4]	Macroinvertebrate	CAR-004	Physical characterization of macroinvertebrates from Community Assessment Reach 4
OU1-MI-CAR004(W)-yymm[4]	Macroinvertebrate	CAR-004	

Table 3. Summary of Container, Preservation, and Hold Requirements for Samples
Phase 2 - Remedial Investigation/Feasibility Study
Matthiessen and Hegeler Zinc Company Site, Operable Unit 1
LaSalle, Illinois

Matrix	Parameter (analysis)	Sample Container	Preservation	Holding Time
Solid (Soil, Sediment, Slag)	TAL Metals (EPA Methods 6010B/6020A/7471B)	1-8 oz WM Jar	Cool to 4 degrees	180 Days (28 Days for Hg)
	TAL Metals SPLP Extraction (EPA Method 1312)	1-8 oz WM Jar (polypropylene)	Cool to 4 degrees	180 Days from Extraction to Analysis (28 Days for Hg)
	Soil pH (EPA method 9045D)	1-4 oz WM Glass Jar	Cool to 4 degrees; No headspace	None - ASAP Preferred (24 hours)
	Trace Metals SEP (Laboratory Specific SOP)	1-250 ml WM Jar (polypropylene)	Cool to 4 degrees	180 Days (28 Days for Hg)
Aqueous	TAL Metals (EPA Methods 6010B/6020A/7470A)	1-1L Plastic (Filtered), 1-1L Plastic (Unfiltered)	Cool to 4 degrees; HNO_3 to pH<2	180 Days (28 Days for Hg)
	Hardness (EPA Method 130.2, 130.1)	100 -ml glass or polypropylene bottle (fill to neck of bottle)	HNO_3 or H_2SO_4 to pH < 2	180 days
Tissue	TAL Metals (EPA Methods 6010B/6020A/7471B)	Ziploc Bag	Freeze at - 20°C	180 Days (28 Days for Mercury)
	Lipid Content	Ziploc Bag	Freeze at - 20°C	1 Year

Notes:
1. C: Centigrade - preservation refers to degrees Centigrade
2. WM: Wide Mouthed
3. TAL: Target Analyte List
4. SEP: Sequential Extraction Procedure
6. EPA: Environmental Protection Agency
7. SOP: Standard Operating Procedure
8. TCLP: Toxicity Characteristic Leaching Procedure
9. ml: Milliliter
10. oz.: Ounce
11. SPLP: Synthetic Precipitation Leaching Procedure
12. Hg: Mercury, As: Arsenic, Cd: Cadmium, Cu: Copper, Pb: Lead, Ag: Silver, and Zn: Zinc

Table 4. Field Quality Control Samples
Remedial Investigation/Feasibility Study
Mattheissen and Hegeler Zinc Company Site, Operable Unit 1
LaSalle, Illinois

Parameter	Matrix	MS/MSD(1)	Equipment Rinsate Blanks(2)*	Filter Blank	Field Blank	Duplicate Samples
TAL Metals	Surface Water / Interstitial Water	1 set/20 samples or less	1 per 20 samples or 1 per day	NA	1 per source or 1 per day	1 per 20 samples or less
Hardness		2 set/20 samples or less	1 per 20 samples or 1 per day	NA	1 per source or 1 per day	1 per 20 samples or less
TAL Metals	Soil/Sediment/ Slag	1 set/20 samples or less (double volume only)	1 per 20 samples or 1 per day	NA	1 per source or 1 per day	1 per 20 samples or less
TAL Metals SPLP		1 set/20 samples or less (double volume only)	1 per 20 samples or 1 per day	NA	NA	1 per 20 samples or less
Trace Metals SEP		NA	NA	NA	NA	1 per 20 samples or
Soil pH		1 set/20 samples or less	1 per 20 samples or 1 per day	NA	NA	1 per 20 samples or less
Arsenic	Biological Tissue	1 per 20 samples or 1 per day	1 per 20 samples or 1 per day	NA	NA	NA
Cadmium						
Copper						
Lead						
Mercury						
Silver						
Zinc						

*If less than 20 samples are collected but two days are required for sample collection; two equipment rinsate samples will be collected.

Notes:
1. Field personnel must collect triple volume to account for MS/MSD sample.
2. No equipment blanks are required for disposable or dedicated field sampling equipment.
3. NA: Not Applicable
4. TAL: Target Analyte List
5. SEP: Sequential Extraction Procedure
6. MS/MSD: Matrix Spike/Matrix Spike Duplicate
7. SPLP: Synthetic Precipitation Leaching Procedure

ATTACHMENT A
IDNR Fisheries Stream Sampling Guidelines

IDNR Fisheries Stream Sampling Guidelines (2001)

IDNR fisheries managers and others involved with the management of Illinois streams need accurate and consistent data on which to base their decisions. Guidelines for IDNR stream sampling help standardize the collection of stream-fish information. Standardized collection allows valid comparisons among sites by minimizing variability in sampling technique. Such comparisons are necessary for effective management and stewardship of stream resources throughout the state. Because Illinois streams differ greatly in physical and biological characteristics, statewide sampling guidelines must be flexible enough to accommodate this variability. These guidelines are intended to optimize data standardization while also accommodating the practical need to adjust sampling procedures to particular situations.

These guidelines were developed for professional, experienced fishery biologists, thoroughly acquainted with the operation, handling and maintenance of the sampling equipment; use of this equipment by inexperienced or uninitiated personnel could result in serious injury.

Background

The baseline and monitoring data collected by the Division of Fisheries provide sport fish population assessments which are important to stream fisheries management and protection (e.g., Sallee et al. 1991, Putman et al. 1995). Additionally, the sampling conducted by Fisheries biologists assists with delineating threatened and endangered species distributions (e.g., Burr et al. 1996) and fish community assessments. As part of the fish community assessments, fisheries data are used for characterizing stream health through the use of the Index of Biotic Integrity (Karr 1981, Karr et al. 1986). Subsequently, the IBI was revised by Hite and Bertrand (1989) and adapted for use in Illinois through the Biological Stream Characterization (BSC) Work Group. The IBI is a major component of the BSC rating of streams (Illinois EPA 1996a) and is used in the Aquatic Life Use-Assessment of the IEPA 305(b) (Illinois EPA 1996b) report to the US EPA, which rates the water quality of Illinois streams. The BSC is also incorporated into the Illinois EPA Targeted Watershed Approach to stream protection and restoration (Illinois EPA 1997).

Stream Sampling Guidelines address the three main objectives of the Division's stream fish sampling. These objectives are: 1) Fish community composition, 2) Sport fishery characterization and 3) Special (targeted) fish studies.

The goal of fish community sampling is to determine the identity and number of fish species present (species richness) and the relative number of individuals of each species (relative abundance) in a stream segment. Because length and weight of individual fish are routinely measured, estimates of species-specific population size and age structure can be obtained. Stream segment fish biomass estimates can also be calculated.

The second objective, Sport fishery characterization, is useful to the Fisheries Division in its strategic planning efforts and for informing the public on sport fishing opportunities in Illinois streams.

Special (targeted) fish studies are conducted to obtain detailed estimates of population size, population age and growth structure, or migration and movement patterns of particular target species. These studies are often conducted with specific management objectives in mind, such as fish stocking assessments, watershed management evaluations or fisheries response to habitat improvement efforts.

Section 1. Station Selection Criteria

Stations should be selected based upon the following criteria:

1. Sites which have been previously sampled (particularly during the 1981 - 1998 cooperative basin survey effort) should receive priority over sites for which no data have been collected.

2. If no historical fisheries data are available, then site selection should be based on general characteristics of stream habitat, location relative to tributaries or point source pollution, relative position within the watershed (e.g., headwaters, middle, mouth). Consideration should be given for ***both*** representative and unique habitats. For example, if a stream is predominantly channelized, then at least one station should be placed in a channelized reach, even if this is not considered the "best" section of the stream.

3. IEPA ambient water quality or macroinvertebrate sampling sites. Typically, IEPA ambient water quality sites have a substantial water chemistry data set and therefore can be supportive for fisheries data.

Section 2. Sampling station selection

A reconnaissance trip is strongly recommended to familiarize the lead biologist with each potential sampling site. During the reconnaissance, the upstream and downstream limits of the sampling station may be determined and noted on the Stream Reconnaissance Form. The information on the reconnaissance forms should be sufficient to allow any IDNR fisheries biologist to lead the sampling. Although stream conditions can change from time of reconnaissance to time of sampling, this information can reduce confusion regarding where the sample is to be collected.

A reasonable attempt must be made to obtain landowner permission prior to sampling. The process of landowner contact can begin during reconnaissance, or by contacting the Natural Resources Conservation Service, in the county in which the stream segment to be sampled is located, to obtain the name, address and telephone number of the landowner in question. Landowners can then be contacted by phone and/or mail for permission to sample. Landowner information should be filed for subsequent sampling efforts.

Stream sampling locations should be chosen based on the physical characteristics, including stream width and depth, that will influence the amount of stream sampled. Stream segments to be sampled should be selected based upon habitat. Habitat diversity will also influence the length of stream sampled.

For non-channelized or old channelized (> 40 years) streams, *at least one* and preferably two to three pool/riffle sequences should be sampled. The number of pool/riffle sequences will depend upon the geological conditions, stream size and other factors, but this should be a minimum goal. No station should be less that 100 meters in length. If the hydraulic habitat is of a homogeneous nature (e.g., channelized), then a minimum of 15-21x normal base-flow width should be sampled. Normal base-flow is that volume of water that occupies the stream channel up to the vegetation (forbs, grasses, shrubs) line.

Setting the Station limits

Using the the habitat criteria listed above, the upstream and downstream limits of the station are blocked with nets. When setting the nets, every effort should be made to avoid disturbing the area to be sampled. Crew members should not enter the area to be sampled until the nets have been secured and should remain downstream of the sampling area to minimize turbidity disturbance. The preferred location for setting the nets are constrictions or upstream limits of riffles. Consideration should be given to the effects of hydraulic modifications to the stream caused by a bridge, because bridges often present anomalous habitat conditions, they should generally be avoided. The nets should be long enouth to block the entire stream width. Net height should be 6 ft and mesh should be 0.25 inch bar measure. Net stakes should be used to prevent the net from collapsing during the sampling. Usually, one stake for every 10 ft of stream width should be used in low flow conditions. More stakes may be required at higher stream discharges. The stakes are to be placed through the lead line and angled upstream. Metal bottom anchors (J-hooks) should be placed through the lead line to minimize fish escape. These may be supplemented with rocks. The float line should be pulled sufficiently taut to keep fish from jumping over the net, but not so tight that the lead line lifts off the stream bottom.

General Stream Conditions for Sampling

To maintain consistency with IDNR historical collections and optimize efficiency, sampling should be conducted during typical summer **low-flow** conditions. This is typically from early July to mid-September, although sampling could be conducted in June in far southern Illinois. Sampling should not be conducted at high flows without sufficient justification. Due to the lack of gauging stations on small-to-intermediate sized streams, it is difficult to develop standardized criteria for determining the range of flows that is acceptable for sampling, rather this is at the discretion of the lead biologist. Fish sampling and habitat data must be collected at the same flow levels, preferably on the same day or contiguous days.

Related to stream flow, water clarity (turbidity) is a critical component to sampling efficiency. Ambient turbidity will vary regionally in Illinois. For example, in south-central Illinois, the presence of clay-ladened soils contributes to high turbidity levels even in low or no-flow conditions. By comparison, northern Illinois streams with rocky substrates, may have very low turbidity even in high flows. Turbidity should be characteristic for low-flow conditions. In eutrophic streams, phytoplankton blooms or floating aquatic macrophytes may also reduce visibility.

General Fish Sampling Procedures

Wadable sampling techniques should be used in streams with a **average depth of 1.5 ft or less.**

Deep pools, up to 3.5 ft may be encountered in these streams, but they should not be common. When flow is present, wadable electrofishing is conducted from downstream to upstream. This is necessary to avoid creating plumes of silt in the area to be sampled. The increased turbidity limits visibility and reduces sampling efficiency. Only in "no-flow" or pooled conditions can sampling in an upstream to downstream direction be considered an option. Boat sampling and minnow seining may be conducted in either direction.

For all electrofishing, the amount of shocking time and length of stream sampled should be recorded. For minnow seining, the number and length of hauls, width of net used for each haul and average depth should be recorded.

When electrofishing, fish should not be kept in the dip nets and repeatedly subjected to the electrical field. Dip net handles must be made of non-conductive fiberglass or similar material and the net mesh should not be larger than 0.25 inch bar measure.
In community sampling, it is extremely important that ALL nettable fish be collected. Every fish is important and could represent another species. To obtain this type of coverage, all representative habitats should be sampled and must be included in the sampling station.

A reasonable effort should be made to keep all fish alive. For most sampling, an oxygen supply is required and to prevent undo stress which may cause mortality, the use of a 0.5% solution (0.04 lbs per gallon) of non-iodized salt is used. For wadable streams an "R" oxygen bottle provides a convenient source. During any electrofishing effort, if it appears that the number of fish is excessive and will result in stressed fish, then fish must either be redistributed to holding containers with adequate oxygen or sampling must be stopped and fish processed. If sampling is stopped, a block net should be placed at the location where sampling is interrupted. Fish should then be processed and released downstream of the station. A floating cage can also be used to hold fish while being processed. Upon completion of fish processing, sampling should then resume upstream of the temporary block net.

Section 3. Fish Sampling Techniques

Gear selection criteria
1) Boat electrofishing, supplemented with minnow seine hauls, is the method of choice when the habitats present within the station can be reasonably sampled with a boat (i.e., motor lower unit does not frequently contact the substrate and there is enough depth to operate the boat).
2) The electric seine (with block nets) should be used when the station is entirely wadeable (average depth is 1.5 ft or less) and narrow enough to block.
3) The backpack shocker (with block nets) is used when conditions won't permit use of boat electrofishing or electric seine (e.g., small headwater streams).

Boat electrofishing
A boat sampling crew should consist of a minimum of two (2) and up to five (5) people. Although only two people (one netter, one motor operator) are able to sample at a time, the additional people can collect water chemistry data and conduct minnow seining. When the electrofishing crew returns to the access site, fish can be processed immediately by two people and electrofishing can continue for the next run.

For small, non-wadable streams a 12'-14' boat is the preferred size as it allows movement over riffles and in confined areas. Dip net mesh size should be .125 to .25 inch. The motor operator and netter must communicate by using a variety of hand signals because generator noise usually precludes verbal communication. The netter and motor operator must watch for underwater obstructions, livestock fences or other potential hazards, and immediately alert one another to their presence. If anglers are encountered, the motor operator should either turn off the electricity to the electrodes or divert course to reduce disturbance.

If sampling is to be conducted upstream and downstream of the access point, then the downstream segment should be sampled first. This will reduce the likelihood of recapturing fish that are processed from the first sampling run. Because the effects of electrofishing differ among fish species, the crew should often check behind the boat for stunned fish. Frequent circling is recommended to assure adequate coverage of the station.

As at wadable sites, the actual length of a boat sampling station will vary with the stream size, habitat diversity and presence of impassable obstructions. Typically, a boat station will cover from 0.25 mile to one (1) mile. The electrofishing crew should sample all available habitats, including open water and midchannel areas, not just shoreline habitats. Electrofishing time must be accurately recorded. The length of stream sampled (combined length along both banks and midchannel) should be estimated (to within 10ft). This can be done on site (with tape measure or rangefinder) or may be measured on USGS topographic 7.5 minute quadrangle. Unlike wadeable sites, boat sampling stations are sampled for a given time (usually 15 or 30 min individual runs), rather than for a pre-determined distance.

When sampling in shallow water it may be necessary to get out of the boat to push the boat or retrieve fish. If this occurs, the power to the electrodes must be turned off before getting out of the boat.

Minnow Seine
The major emphasis of minnow seine sampling is to determine species occurrences. Minnow seine samples are usually collected to supplement boat electrofishing samples. A minnow seine crew should have a minimum of two (2) and optimally three (3) people. Minnow seining should not be the exclusive gear for non-headwater streams (>10 ft) wide. In headwater streams, conditions may be conducive for efficient minnow seining because stream width and depth allow sufficient 'sampling space' for this method. The length of seine used will vary with stream conditions, depth should be 6 ft and mesh should be 0.125 to 0.25 inch (bar measure). For pool or run conditions, an area relatively clear of obstructions should be selected. Sampling may be conducted either in an upstream or downstream direction. Number and length(s) of seine hauls should be recorded with the fish data. Circular sweeps allow sampling where debris or other obstructions restrict linear sampling. Riffles or deep, fast runs can be sampled by placing the net across the riffle and having a crew member kick from upstream towards the net. If it is a large riffle, select an area up to 15 ft in width and place the net across that area. Then, one or more persons should walk upstream approximately 20 ft and begin kicking the substrate; moving downstream toward the net . When they arrive at the net, “kickers” should reach into the water, find the lead line and purse the net.

For all minnow seine sampling, it is very important that the lead line be kept on the bottom. If an impediment is encountered during a haul, attempts should be made to quickly dislodge or bypass the obstruction. When beaching the seine, keep the lead line pressed to the substrate and pull the seine towards shore. Quickly remove all fish from the seine and process (or preserve). The number and length(s) of seine hauls should be recorded with the fish data.

Electric Seine

For electric seine sampling, the crew should consist of a minimum of five (5) persons with an optimum of six (6). One (1) person is responsible for generator operation and assuring that fish are kept oxygenated. Three (3) members of the crew net fish and two (2) members operate the brails of the electric seine. Skilled brail operators may also opt to carry a dip net for maximum efficiency in confined areas. All persons will wear heavy duty (lineman) rubber gloves and either hip boots or chest waders (preferred). Prior to activating the seine, one of the brail operators must indicate verbally that the seine is going to be turned “ON”. Similarly, when it is turned “OFF” one of the operators must indicate that the seine is “OFF”.

The pace of sampling should accommodate the netters so that when large numbers of fish are present, the operators should reduce forward progress until fish have been netted and placed in live wells. When appropriate, brush, logs, or shoreline cover should be sampled by having one or both of the brail operators wrap around the cover. The netters should keep pace with the brail operators as they surround the object, to collect stunned fish. Using their dip nets, the netters may need to push the electric seine into the brush or deeper pool to assure full coverage. After this process, the seine could briefly be turned off for the crew to regroup.

If the stream is wider than the electric seine the sampling crew should follow the thalweg, concentrating on instream cover and minimizing deep water fish escape routes. If depth is sufficient across the channel, a second pass may be needed to cover the "unsampled" side.

Riffles should be sampled by first carrying the electric seine upstream of the riffle and having the netters place the nets side by side at the downstream end of the riffle. The brail operators, with the seine “ON”, should then kick the riffle to dislodge fish. Depending upon the length of the riffle, this could be done multiple times. If time and manpower allows, a minnow seine can be positioned below the riffle instead of or in addition to side by side dip nets.

Backpack Electrofisher

The backpack electrofishing crew will consist of a minimum of two (2) persons, with three (3) optimal. One person will operate the backpack, one person will net fish and carry a bucket to hold stunned fish. Block nets will be set as noted above. All persons will wear rubber gloves and either hip boots or chest waders. Electrofishing settings will be contingent upon water conditions including conductivity and depth, but settings should be sufficient to optimize collection, but to minimize harm to fish.

Backpack shocking is generally done in an upstream direction for reasons noted above. For optimal catch efficiency, the anode probe is thrust into cover (e.g.,undercut bank, log jam) with the power "OFF", then drawn slowly back to the operator with the power "ON". This minimizes scaring fish and utilizes the galvanotaxic response of fish to DC current.

Section 4. Habitat and Methods Data

Procedures for completion of stream investigation forms and stream methods and habitat form are in the Operations Manual - FDM 6230 and FDM 6230.1, respectively.

Section 5. Fish Workup

1) Small fishes (e.g. minnows, darters and y-o-y sunfishes) and fishes not easily identified should be preserved in 10% formalin as quickly as possible for ease of identification and value as voucher specimens. Make sure preserved samples are clearly labeled with sampling location, method and date.

2) Weigh and measure length of all fishes greater than or equal to 6", measure length of smaller fishes

3) All reasonable effort should be made to return fish alive back to the stream.

4) Dead fish should be buried (preferred) or scattered throughout the surrounding area at least 50 ft from the stream in areas unlikely to cause inconvenience to stream users or landowners.

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ATTACHMENT B
IEPA Established Field Collection Protocols

Methods of Sampling Macroinvertebrates in Streams

A. Methods of sampling stream macroinvertebrates for determining biological integrity

A-1. General instructions

A-1.1 Sample macroinvertebrates during June 1 through October 15.

A-1.2 Select a sampling reach that:

- has instream and riparian habitat conditions typical of the entire assessment reach,
- has flow conditions that approximate typical summer base flow,
- has no highly influential tributary streams,
- contains at least one riffle/pool sequence or analog (i.e., run/bend meander or alternate point-bar sequence), if present, **AND**,

where the multi-habitat method is applicable (see below),

- is at least 300 feet long

A-1.3 Determine applicability of the multi-habitat method.

The multi-habitat method is applicable if :

- Conditions allow the sampler to collect macroinvertebrates (i.e., to take dips with a dipnet) in **all** bottom-zone and bank-zone habitat types that occur in the sampling reach. These habitat types are defined explicitly later in this document.

  AND

- Conditions allow the sampler to apply the 11-transect habitat-sampling method, as described in *"Wadable Streams Transect Approach"* in *Appendix 1, Section E: Stream Habitat and Discharge Monitoring*, in *Quality Assurance Project Plan* (Illinois EPA 1994) or to estimate with reasonable accuracy--via visual or tactile cues--the amount of each of several bottom-zone and bank-zone habitat types. If conditions (e.g., inaccessibility, water turbidity, or excessive water depths) prohibit the sampler from estimating with reasonable accuracy the composition of the bottom zone or bank zone throughout the entire sampling reach, then the multi-habitat method is not applicable. Typically, if more than half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler, it is unlikely that reasonably accurate estimates of the bottom-zone and bank-zone habitat types are attainable; thus, the multi-habitat method is not applicable.

A-2. The multi-habitat method of sampling stream macroinvertebrates

The multi-habitat method of sampling stream macroinvertebrates (hereafter called the "multi-habitat method") provides information useful for determining the biological integrity of a stream, as reflected in selected attributes of the macroinvertebrate assemblage living in the stream. These biological attributes represent how macroinvertebrates respond to and integrate the chemical, physical, and biological effects of human-caused impacts (both negative and positive) on streams and their watersheds, e.g., point- or nonpoint-source impacts, stream-restoration efforts. The multi-habitat method allocates sampling effort based on the relative amounts of several predefined macroinvertebrate habitat types that occur in the sampling reach.

A-2.1 Identify several predefined macroinvertebrate-habitat types (listed below) based on conditions at the time of macroinvertebrate sampling. Determine the amount of each habitat type in the sampling reach:

Bottom-zone habitat types (four types):

- Fine substrate: streambed surface predominantly comprising silt/mud to fine gravel (i.e., particles < 8mm in diameter of intermediate dimension)

- Coarse substrate: streambed surface predominantly comprising medium gravel to boulder (i.e., particles $\geq$ 8 mm in diameter of intermediate dimension)

- Plant detritus: streambed surface predominantly comprising nonliving plant material (e.g., leaves, twigs)

- Vegetation: streambed surface predominantly comprising living plant material (e.g., aquatic macrophytes, filamentous algae, submerged terrestrial plants)

Bank-zone habitat types (three types):

- Submerged terrestrial vegetation: living, terrestrial plants (along stream banks) of which submerged portions provide cover or attachment sites for macroinvertebrates

- Submerged tree roots: living tree roots (along stream banks) of which submerged portions provide cover or attachment sites for macroinvertebrates.

- Brush-debris jams: non-living, submerged, woody material (e.g., branches, twigs, or smaller logs) that occurs above the streambed surface and that appears to have microbial conditioning. Excludes recent deadfall that lacks microbial conditioning.

A-2.1.1 For qualified, trained personnel having fewer than 2 years of experience in measuring and characterizing instream physical habitat (including stream-bottom composition) for purposes of natural-resource management, use the 11-transect habitat method to determine the amount of each habitat type:

- When applicable, measure and estimate habitat conditions by applying the appropriate parts of the 11-transect habitat method as described in *"Wadable Streams Transect Approach"* in *Appendix 1, Section E: Stream Habitat and Discharge Monitoring*, in *Quality Assurance Project Plan* (Illinois EPA, 1994). Specifically, use the 11-transect method to identify the "substrate" (see below) or "bottom type" (see below) at each of many points distributed regularly on the wetted stream bottom throughout the entire sampling reach. Also, per each of ten segments in the sampling reach, visually estimate the length of space occupied by each of the "instream cover type"s.

Substrates:

Name	Particle-Size Range
Silt/mud	< 0.062 mm
Sand	0.062 – 2 mm
Fine gravel	2 – 8 mm
Medium grave l	8 – 16 mm
Coarse gravel	16 – 64 mm
Small cobble	64 – 128 mm
Large cobble	128 – 256 mm
Boulder	256 – 4000 mm
Bedrock	> 4000 mm

Instream Cover Types:

Submerged terrestrial vegetation
Submerged tree roots
Brush-debris jam
Boulder (not embedded)
Undercut bank
Rock/clay ledge
Log
Aquatic vegetation
Other (please specify)

Bottom Types:

Claypan/Compacted soil
Plant detritus
Vegetation
Submerged log
Other (please specify)

- Based on the definition of each bottom-zone habitat type (see section A-2.1), translate each of the observations of "substrate" and "bottom type" into the appropriate bottom-zone habitat type and calculate and record the relative percentage of each bottom-zone habitat type in the sampling reach as:

Relative percentage of each bottom-zone habitat type =

Sum of the points (from all transects) at which the bottom-zone habitat type occurred	÷	*Sum of the points (from all transects) at which any of the four bottom-zone habitat types occurred*	**x 100**

- When using the 11-transect habitat method, spatial coverage of each bank-zone habitat type is visually estimated within each of the ten stream segments delineated by the eleven transects. Estimate and record *Submerged terrestrial vegetation* and *Submerged tree roots* as the length of bank covered by each habitat type in the sampling reach. For estimating the amount of *Brush-debris jams* in the sampling reach, consider all brush-debris jams as bank-zone habitat, regardless of occurrence within the assumed bank zone (see Table 1)—provided that the brush-debris jam occurs at a depth and water velocity that allow safe and sufficient sampling of macroinvertebrates with a dipnet. Estimate the single longest dimension covered by each brush-debris jam and then sum these lengths to yield the total length of *Brush-debris jams*.

- If water turbidity or excessive depth prevents seeing the entire wetted stream channel throughout the sampling reach, the sampler may use tactile cues to obtain a reasonably accurate estimate of the amount of each bank-zone habitat type. However, in most cases, if more than half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler, it is unlikely that reasonably accurate estimates of these amounts are attainable; thus, the multi-habitat method is not applicable.

A-2.1.2 For qualified, trained personnel having 2 or more years of experience in measuring and characterizing instream physical habitat (including stream-bottom composition) for purposes of natural-resource management, use either of the following two approaches to determine the amount of each habitat type.

A-2.1.2.1 Visual-estimation approach

- Wade, walk the stream banks, or float (via boat or canoe) the sampling reach and visually estimate and record the percent surface area of the relevant portion of wetted stream bottom that consists of each of the four bottom-zone habitat types. The relevant portion is the portion of wetted stream bottom that consists of any of the four types of bottom-zone habitat. For example, because claypan is not considered as a bottom-zone habitat type for applying the multi-habitat method, the area of wetted stream bottom that consists of claypan should be ignored (in the denominator) when estimating the relative percentage of wetted stream bottom consisting of each of the four bottom-zone habitat types.

- Wade, walk the stream banks, or float (via boat or canoe) the sampling reach and visually estimate and record the length of space occupied by each of the three bank-zone habitat types. Estimate and record *Submerged terrestrial vegetation* and *Submerged tree roots* as the length of bank covered by each habitat type in the sampling reach. For estimating the amount of *Brush-debris jams* in the sampling reach, consider all brush-debris jams as bank-zone habitat, regardless of occurrence within the assumed bank zone (see Table 1)—provided that the brush-debris jam occurs at a depth and water velocity that allow safe and sufficient sampling of macroinvertebrates with a dipnet. Estimate the single longest dimension covered by each brush-debris jam and then sum these lengths to yield the total length of *Brush-debris jams*.

- If water turbidity or excessive depth prevents seeing the entire wetted stream channel throughout the sampling reach, the sampler may use tactile cues or knowledge of the channel morphology and streambed to obtain a reasonably accurate estimate of the amount of each bottom-zone and each bank-zone habitat type. However, in most cases, if more than half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler, it is unlikely that reasonably accurate estimates of these amounts are attainable; thus, the multi-habitat method is not applicable

A-2.1.2.2 Point-transect approach

- When applicable, measure and estimate habitat conditions by applying the appropriate parts of the 11-transect habitat method as described in *"Wadable Streams Transect Approach"* in *Appendix 1, Section E: Stream Habitat and Discharge Monitoring*, in *Quality Assurance Project Plan* (Illinois EPA, 1994). Specifically, use the 11-transect method to identify the "substrate" (see A-2.1.1 above) or "bottom type" (see A-2.1.1 above) at each of many points distributed regularly on the wetted stream bottom throughout the entire sampling reach. Also, per each of ten segments in the sampling reach, visually estimate the length of space occupied by each of the "instream cover type"s (see A-2.1.1 above).

- Based on the definition of each bottom-zone habitat type (see A-2.1 above), translate each of the observations of "substrate" and "bottom type" into the appropriate bottom-zone habitat type and calculate and record the relative percentage of each bottom-zone habitat type in the sampling reach as:

Relative percentage of each bottom-zone habitat type =

$$\left[\frac{\textit{Sum of the points (from all transects) at which the bottom-zone habitat type occurred}}{\textit{Sum of the points (from all transects) at which any of the four bottom-zone habitat types occurred}} \right] \times 100$$

- When using the 11-transect habitat method, spatial coverage of each bank-zone habitat type is visually estimated within each of the ten stream segments delineated by the eleven transects. Estimate and record *Submerged terrestrial vegetation* and *Submerged tree roots* as the length of bank covered by each habitat type in the sampling reach. For estimating the amount of *Brush-debris jams* in the sampling reach, consider all brush-debris jams as bank-zone habitat, regardless of occurrence within the assumed bank zone (see Table 1)—provided that the brush-debris jam occurs at a depth and water velocity that allow safe and sufficient sampling of macroinvertebrates with a dipnet. Estimate the single longest dimension covered by each brush-debris jam and then sum these lengths to yield the total length of *Brush-debris jams*.

- If water turbidity or excessive depth prevents seeing the entire wetted stream channel throughout the sampling reach, the sampler may use tactile cues to obtain a reasonably accurate estimate of the amount of each bank-zone habitat type. However, in most cases, if more than half of the wetted stream channel cannot be seen, touched, or otherwise reliably characterized by the sampler, it is unlikely that reasonably accurate estimates of these amounts are attainable; thus, the multi-habitat method is not applicable.

A-2.2 Allocate effort for the multi-habitat method:

- Allocate 20 dips of effort to the bank zone and bottom zone. Based on mean wetted width of the sampling reach, determine the number of dips to perform in the each zone by consulting Table 1. If the 11-transect habitat method was not used, calculate mean wetted width based on measurement of the wetted width of at least three transects judged to reflect best the wetted width of the entire sampling reach.

- For sampling within the bank zone or within the bottom zone, further allocate dips based on the relative amounts of each corresponding habitat type (from sections A-2.1.1 and A-2.1.2). For each habitat type in each zone (bottom or bank), transform the relative amount into the number of dips to perform as follows:

Number of dips to perform in a particular bottom-zone or bank-zone habitat type =

$$\left[\frac{\textit{Percentage or length of habitat type}}{\textit{Sum of percentages or lengths of all habitat types}} \right] \times \textit{Number of dips allocated (from Table 1)}$$

For each zone, if the relative percentage of the habitat type is less than 5%, do not allocate dips to that type. When transforming relative amounts of habitat types into numbers of dips, round to the nearest whole number. If rounding results in more than 20 dips for the total allocation across all habitat types, decrease the number of dips allocated to the most-abundant habitat type to limit the total to 20. Record the number of dips allocated to each bottom-zone habitat type and each bank-zone habitat type.

For example, for a stream having a mean wetted width of 37 feet, 14 dips are required from bottom-zone habitats and 6 dips are required from bank-zone habitats. Suppose the percent surface areas of the four bottom-zone habitat types are 48% *Fine substrate*, 32% *Coarse substrate*, 7% *Plant detritus*, and 13% *Vegetation* (please note that these percentages must sum to 100% because they are based only on the portion of stream bottom that consists of any of the four habitat types). Based on these amounts, the 14 bottom-zone dips should be allocated as:
7 dips in *Fine substrate* ($[48 \div 100] \times 14 = 6.72 \cong 7$), 4 dips in *Coarse substrate*, 1 dip in *Plant detritus*, and 2 dips in *Vegetation*.
Suppose the lengths of the three bank-zone habitat types are 5 ft. of *Submerged terrestrial vegetation*, 100 ft. of *Submerged tree roots*, and 50 ft. of *Brush-debris jams*. Based on these amounts, the 6 bank-zone dips should be allocated as: 4 dips in S*ubmerged tree roots* and 2 dips in *Brush-debris jams*. An insufficient relative amount (i.e., (5)/(5+100+50) = 3.2%, which is $\leq$ 5%) of *Submerged terrestrial vegetation* occurs to allocate even a single dip.

Table 1. Bank-zone and bottom-zone sampling-effort allocation.

Mean wetted width (to nearest foot)	Assumed width of bank-zone	Bank-zone dips	Bottom-zone dips
< 10 ft	25% of wetted width per bank	10	10
10-29 ft	20% of wetted width per bank	8	12
30-59 ft	15% of wetted width per bank	6	14
60-99 ft	10% of wetted width per bank	4	16
≥100 ft	5% of wetted width per bank	2	18

A-2.3 Perform the 20 dips.

A-2.3.1 General guidelines:

- One person performs all 20 dips.

- For each habitat type, take dips in the most-productive, stable areas. Most-productive areas generally occur where current velocity is relatively high. To minimize the potential for sampling bias attributable to uneven spatial distribution of macroinvertebrates throughout an entire stream reach, distribute multiple dips in (most-productive, stable areas of) each habitat type as evenly as possible throughout the sampling reach. For each habitat type, if there is not enough sampling area to perform all of the allocated dips, then reallocate the remaining dips among the remaining habitat types in that zone. Reallocate these remaining dips as proportionately as possible to the original allocations.

A-2.3.2 Specific instructions:

- Use an 18x8-inch rectangular net with a Standard #30 (600-micron) mesh net.

- To perform a dip, place the net immediately downstream from the target area of the appropriate bottom-zone or bank-zone habitat type and dislodge macroinvertebrates by disturbing an 18x18-inch area. At higher water velocities, dislodged macroinvertebrates will be flushed directly into the stationary net. At lower velocities, capture dislodged macroinvertebrates by repeatedly sweeping the net directly above or adjacent to the 18x18-inch disturbed area. Always sweep in an upstream direction.

- When sampling fine-particle streambed substrates (e.g., silt/mud, sand), disturb the upper 1-inch of streambed in an 18x18-inch area by repeatedly bumping the leading edge of the net along the streambed surface. Complete the dip by capturing macroinvertebrates that are suspended over the sampling area by repeatedly sweeping upstream through the water column.

- Large pieces of wood or boulders may be sampled if they occupy the 18x18-inch sampling area **AND** if their dimensions would allow fitting these objects into the dipnet. When sampling these objects, wash, brush, or pick surface-clinging organisms into the dipnet and include them as part of the sample; do not retain the object in the sample.

- Between dips (as needed), combine the dipnet contents into a standard #30 (600-micron) sieve bucket (i.e., sample container). Before transferring dipnet contents to the sample container, excess debris or sediment may be removed only after first retaining all attached organisms. Removal of excess debris and sediment at this step greatly facilitates laboratory subsampling and sorting of the preserved sample. If necessary, transfer dipnet contents to a different sieve bucket or other suitable container and vigorously agitate, rinse, brush, or pick (as needed) to remove organisms from the debris; discard the debris only after ensuring that organisms have been removed. After "rinsing" and removing debris, transfer contents to the sample container.

- After performing all 20 dips and combining the contents into the sample container, transfer sample-container contents to an appropriate leak-proof jar(s) and preserve it with 95% ethanol. Label the container appropriately. If a sample contains large amounts of organic debris, check for sufficient preservation within five days (or sooner) of initial “fixing”; decant old fluid and add more 95% ethanol as needed to ensure sufficient preservation. Thereafter, periodically check the sample and re-preserve as needed.

APPENDIX B

QHEI Forms

[redacted] Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 84

River Code: ______ **RM:** ______ **Stream:** LVR
Station ID: ______ **Location:** CARØØ4
Date: ______ **Scorer:** ______ **Latitude:** ______ **Longitude:** ______

1] SUBSTRATE (Check ONLY Two SubstrateTYPE BOXES; Estimate % present

TYPE	POOL RIFFLE	TYPE	POOL RIFFLE	SUBSTRATE ORIGIN Check ONE (OR 2 & AVERAGE)	SUBSTRATE QUALITY Check ONE (OR 2 & AVERAGE)
☐☐-BLDR /SLBS[10]		☐☒-GRAVEL [7]		☒-LIMESTONE [1]	SILT: ☐-SILT HEAVY [-2]
☐☐-Lg BOULD. [10]		☐☐-SAND [6]		☐-TILLS [1]	☐-SILT MODERATE [-1]
☐☐-BOULDER [9]		☐☐-BEDROCK[5]		☐-WETLANDS[0]	☒-SILT NORMAL [0]
☐☒-COBBLE [8]		☐☐-DETRITUS[3]		☐-HARDPAN [0]	☐-SILT FREE [1]
☐☐-HARDPAN [4]		☐☐-ARTIFICIAL[0]		☐-SANDSTONE [0]	EMBEDDEDNESS: ☐-EXTENSIVE [-2]
☐☐-MUCK [2]		☐☐-SILT [2]		☐-RIP/RAP [0]	☐-MODERATE [-1]
				☐-LACUSTRINE [0]	☒-NORMAL [0]
				☐-SHALE [-1]	☐-NONE [1]
				☐-COAL FINES [-2]	

NUMBER OF SUBSTRATE TYPES: ☒-4 or More [2] ☐-3 or Less [0]
(High Quality Only, Score 5 or >)

COMMENTS sand, gravel, cobble, boulder present

Substrate **18** Max 20

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)

(Structure) **TYPE:** Score All That Occur

- 0 UNDERCUT BANKS [1]
- 2 OVERHANGING VEGETATION [1]
- 1 SHALLOWS (IN SLOW WATER) [1]
- 2 ROOTMATS [1]
- 2 POOLS> 70 cm [2]
- 1 ROOTWADS [1]
- 0 BOULDERS [1]
- 0 OXBOWS, BACKWATERS [1]
- 1 AQUATIC MACROPHYTES [1]
- 2 LOGS OR WOODY DEBRIS [1]

COMMENTS: ______

AMOUNT: (Check ONLY One or check 2 and AVERAGE)
- ☐ - EXTENSIVE > 75% [11]
- ☒ - MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

Cover **15** Max 20

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☒ - NONE [6]	☐ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☒ - MODERATE [3]	☒ - GOOD [5]	☐ - RECOVERED [4]	☒ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☐ - RECOVERING [3]	☐ - LOW [1]	☐ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☒ - BANK SHAPING
		☐ - IMPOUNDED [-1]		☒ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: rip-rap on left descending bank

Channel **16** Max 20

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH L R (Per Bank)	FLOOD PLAIN QUALITY (PAST 100 Meter RIPARIAN) L R (Most Predominant Per Bank)	L R	BANK EROSION L R (Per Bank)
☒☒ - VERY WIDE > 100m [5]	☐☐-FOREST, SWAMP [3]	☐☐-CONSERVATION TILLAGE [1]	☐☐-NONE/LITTLE [3]
☐☐ - WIDE > 50m [4]	☒☒-SHRUB OR OLD FIELD [2]	☐☐-URBAN OR INDUSTRIAL [0]	☒☒-MODERATE [2]
☐☐ - MODERATE 10-50m [3]	☐☐-RESIDENTIAL,PARK,NEW FIELD [1]	☐☐-OPEN PASTURE,ROWCROP [0]	☐☐-HEAVY/SEVERE[1]
☐☐ - NARROW 5-10 m [2]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐ - VERY NARROW <5 m[1]			
☐☐ - NONE [0]			

Comments: ______

Riparian **9** Max 10

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)	MORPHOLOGY (Check 1 or 2 & AVERAGE)	CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)	
☒ - >1m [6]	☐-POOL WIDTH > RIFFLE WIDTH [2]	☐-EDDIES[1]	☐-TORRENTIAL[-1]
☐ - 0.7-1m [4]	☒-POOL WIDTH = RIFFLE WIDTH [1]	☐-FAST[1]	☐-INTERSTITIAL[-1]
☐ - 0.4-0.7m [2]	☐-POOL WIDTH < RIFFLE W. [0]	☒-MODERATE [1]	☐-INTERMITTENT[-2]
☐ - 0.2- 0.4m [1]	☐-IMPOUNDED [-1]	☒-SLOW [1]	☐-VERY FAST[1]
☐ - < 0.2m [POOL=0]	COMMENTS:	☐-NONE [-1]	

Pool/ Current **9** Max 12

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH	RUN DEPTH	RIFFLE/RUN SUBSTRATE	RIFFLE/RUN EMBEDDEDNESS
☒ - Best Areas >10 cm [2]	☒ - MAX > 50 [2]	☒-STABLE (e.g.,Cobble, Boulder) [2]	☐ - NONE [2]
☐ - Best Areas 5-10 cm[1]	☐ - MAX < 50[1]	☐-MOD. STABLE (e.g.,Large Gravel) [1]	☒ - LOW [1]
☐ - Best Areas < 5 cm		☐-UNSTABLE (Fine Gravel,Sand) [0]	☐ - MODERATE [0]
☐ - NO RIFFLE [Metric=0]			☐ - EXTENSIVE [-1]

COMMENTS ______

Riffle/Run **7** Max 8

Gradient **10** Max 10

6] GRADIENT (ft/mi): 9.5 DRAINAGE AREA (sq.mi.) : ~120 %POOL: 30 %GLIDE: 40 %RIFFLE: 15 %RUN: 15

*' Best areas must be large enough to support a population of riffle-obligate species

Modified 06/01/2005

Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 83

River Code: ________ **RM:** ________ **Stream:** LVR
Station ID: ________ **Location:** CARØØ3
Date: ________ **Scorer:** ________ **Latitude:** ________ **Longitude:** ________

1] SUBSTRATE (Check ONLY Two SubstrateTYPE BOXES; Estimate % present

TYPE	POOL RIFFLE		POOL RIFFLE	SUBSTRATE ORIGIN Check ONE (OR 2 & AVERAGE)		SUBSTRATE QUALITY Check ONE (OR 2 & AVERAGE)
☐ ☐-BLDR /SLBS[10]		☐ ☐-GRAVEL [7]		☑-LIMESTONE [1]	SILT:	☐-SILT HEAVY [-2]
☐ ☐-Lg BOULD. [10]		☐ ☐-SAND [6]		☐-TILLS [1]		☐-SILT MODERATE [-1]
☐ ☑-BOULDER [9]		☐ ☐-BEDROCK[5]		☐-WETLANDS[0]		☑-SILT NORMAL [0]
☑ ☐-COBBLE [8]		☐ ☐-DETRITUS[3]		☐-HARDPAN [0]		☐-SILT FREE [1]
☐ ☐-HARDPAN [4]		☐ ☐-ARTIFICIAL[0]		☐-SANDSTONE [0]	EMBEDDEDNESS:	☐-EXTENSIVE [-2]
☐ ☐-MUCK [2]		☐ ☐-SILT [2]		☐-RIP/RAP [0]		☐-MODERATE [-1]
				☐-LACUSTRINE [0]		☑-NORMAL [0]
				☐-SHALE [-1]		☐-NONE [1]
				☐-COAL FINES [-2]		

NUMBER OF SUBSTRATE TYPES: ☑-4 or More [2] ☐-3 or Less [0]
(High Quality Only, Score 5 or >)

COMMENTS bedrock, cobble, gravel, boulder present

Substrate: 20 (Max 20)

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)

(Structure) TYPE: Score All That Occur

- 0 UNDERCUT BANKS [1]
- 2 OVERHANGING VEGETATION [1]
- 1 SHALLOWS (IN SLOW WATER) [1]
- 1 ROOTMATS [1]
- 2 POOLS> 70 cm [2]
- 1 ROOTWADS [1]
- 2 BOULDERS [1]
- 0 OXBOWS, BACKWATERS [1]
- 0 AQUATIC MACROPHYTES [1]
- 1 LOGS OR WOODY DEBRIS [1]

COMMENTS:

AMOUNT: (Check ONLY One or check 2 and AVERAGE)
- ☐ - EXTENSIVE > 75% [11]
- ☑ - MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

Cover: 15 (Max 20)

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☐ - NONE [6]	☑ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☑ - MODERATE [3]	☑ - GOOD [5]	☑ - RECOVERED [4]	☐ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☐ - RECOVERING [3]	☐ - LOW [1]	☐ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☐ - BANK SHAPING
		☐- IMPOUNDED [-1]		☑ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: slag on right descending bank

Channel: 15 (Max 20)

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH L R (Per Bank)	FLOOD PLAIN QUALITY (PAST 100 Meter RIPARIAN) L R (Most Predominant Per Bank)	L R	BANK EROSION L R (Per Bank)
☑ ☐ - VERY WIDE > 100m [5]	☑ ☐-FOREST, SWAMP [3]	☐ ☐-CONSERVATION TILLAGE [1]	☑ ☑-NONE/LITTLE [3]
☐ ☐ - WIDE > 50m [4]	☐ ☐-SHRUB OR OLD FIELD [2]	☐ ☐-URBAN OR INDUSTRIAL [0]	☐ ☐-MODERATE [2]
☐ ☐ - MODERATE 10-50m [3]	☐ ☐-RESIDENTIAL,PARK,NEW FIELD [1]	☐ ☐-OPEN PASTURE,ROWCROP [0]	☐ ☐-HEAVY/SEVERE[1]
☐ ☑ - NARROW 5-10 m [2]	☐ ☐-FENCED PASTURE [1]	☐ ☑-MINING/CONSTRUCTION [0]	
☐ ☐ - VERY NARROW <5 m[1]			
☐ ☐ - NONE [0]			

Comments:

Riparian: 8 (Max 10)

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)	MORPHOLOGY (Check 1 or 2 & AVERAGE)	CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)	
☑ - >1m [6]	☑-POOL WIDTH > RIFFLE WIDTH [2]	☐-EDDIES[1]	☐-TORRENTIAL[-1]
☐ - 0.7-1m [4]	☐-POOL WIDTH = RIFFLE WIDTH [1]	☑-FAST[1]	☐-INTERSTITIAL[-1]
☐ - 0.4-0.7m [2]	☐-POOL WIDTH < RIFFLE W. [0]	☑-MODERATE [1]	☐-INTERMITTENT[-2]
☐ - 0.2- 0.4m [1]	☐-IMPOUNDED [-1]	☑-SLOW [1]	☐-VERY FAST[1]
☐ - < 0.2m [POOL=0]	COMMENTS:	☐-NONE [-1]	

Pool/Current: 11 (Max 12)

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH	RUN DEPTH	RIFFLE/RUN SUBSTRATE	RIFFLE/RUN EMBEDDEDNESS
☑ - Best Areas >10 cm [2]	☑ - MAX > 50 [2]	☑-STABLE (e.g.,Cobble, Boulder) [2]	☑ - NONE [2]
☐ - Best Areas 5-10 cm[1]	☐ - MAX < 50[1]	☐-MOD. STABLE (e.g.,Large Gravel) [1]	☐ - LOW [1]
☐ - Best Areas < 5 cm		☐-UNSTABLE (Fine Gravel,Sand) [0]	☐ - MODERATE [0]
☐ - NO RIFFLE [Metric=0]			☐ - EXTENSIVE [-1]

COMMENTS

Riffle/Run: 8 (Max 8)

Gradient: 6 (Max 10)

6] GRADIENT (ft/mi): 18 DRAINAGE AREA (sq.mi.) : ~122

%POOL: 30 %GLIDE: 10
%RIFFLE: 30 %RUN: 30

*' Best areas must be large enough to support a population of riffle-obligate species

Modified 06/01/2005

[redacted]

Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 79

River Code: ______ **RM:** ______ **Stream:** LVR
Station ID: ______ **Location:** CAR002
Date: ______ **Scorer:** ______ **Latitude:** ______ **Longitude:** ______

1] SUBSTRATE (Check ONLY Two SubstrateTYPE BOXES; Estimate % present

TYPE	POOL RIFFLE		POOL RIFFLE	SUBSTRATE ORIGIN (Check ONE (OR 2 & AVERAGE))		SUBSTRATE QUALITY (Check ONE (OR 2 & AVERAGE))
☐☐-BLDR /SLBS[10]	☑☐-GRAVEL [7]			☐-LIMESTONE [1] ☑	SILT:	☐-SILT HEAVY [-2]
☐☐-Lg BOULD. [10]	☐☐-SAND [6]			☐-TILLS [1]		☐-SILT MODERATE [-1]
☐☑-BOULDER [9]	☐☐-BEDROCK[5]			☐-WETLANDS[0]		☑-SILT NORMAL [0]
☐☐-COBBLE [8]	☐☐-DETRITUS[3]			☐-HARDPAN [0]		☐-SILT FREE [1]
☐☐-HARDPAN [4]	☐☐-ARTIFICIAL[0]			☐-SANDSTONE [0]	EMBEDDEDNESS:	☐-EXTENSIVE [-2]
☐☐-MUCK [2]	☐☐-SILT [2]			☐-RIP/RAP [0]		☐-MODERATE [-1]
				☐-LACUSTRINE [0]		☑-NORMAL [0]
				☐-SHALE [-1]		☐-NONE [1]
				☐-COAL FINES [-2]		

NUMBER OF SUBSTRATE TYPES: ☑-4 or More [2] ☐-3 or Less [0]
(High Quality Only, Score 5 or >)

COMMENTS: bedrock, cobble, gravel, boulder present

Substrate: **19** Max 20

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)

(Structure) TYPE: Score All That Occur

- 0 UNDERCUT BANKS [1]
- 1 OVERHANGING VEGETATION [1]
- 1 SHALLOWS (IN SLOW WATER) [1]
- 1 ROOTMATS [1]
- 2 POOLS> 70 cm [2]
- 0 ROOTWADS [1]
- 2 BOULDERS [1]
- 0 OXBOWS, BACKWATERS [1]
- 1 AQUATIC MACROPHYTES [1]
- 1 LOGS OR WOODY DEBRIS [1]

COMMENTS: ______

AMOUNT: (Check ONLY One or check 2 and AVERAGE)
- ☐ - EXTENSIVE > 75% [11]
- ☑ - MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

Cover: **15** Max 20

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☐ - NONE [6]	☑ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☑ - MODERATE [3]	☑ - GOOD [5]	☑ - RECOVERED [4]	☐ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☑ - RECOVERING [3]	☐ - LOW [1]	☐ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☐ - BANK SHAPING
		☐ - IMPOUNDED [-1]		☑ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: slag on right descending bank

Channel: **14.5** Max 20

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH L R (Per Bank)	FLOOD PLAIN QUALITY (PAST 100 Meter RIPARIAN) L R (Most Predominant Per Bank)	L R	BANK EROSION L R (Per Bank)
☑☐ - VERY WIDE > 100m [5]	☑☐-FOREST, SWAMP [3]	☐☐-CONSERVATION TILLAGE [1]	☑☑-NONE/LITTLE [3]
☐☐ - WIDE > 50m [4]	☐☐-SHRUB OR OLD FIELD [2]	☐☑-URBAN OR INDUSTRIAL [0]	☐☐-MODERATE [2]
☐☑ - MODERATE 10-50m [3]	☐☐-RESIDENTIAL, PARK, NEW FIELD [1]	☐☐-OPEN PASTURE, ROWCROP [0]	☐☐-HEAVY/SEVERE[1]
☐☐ - NARROW 5-10 m [2]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐ - VERY NARROW <5 m[1]			
☐☐ - NONE [0]			

Comments: ______

Riparian: **8.5** Max 10

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)	MORPHOLOGY (Check 1 or 2 & AVERAGE)	CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)	
☑ - >1m [6]	☑-POOL WIDTH > RIFFLE WIDTH [2]	☐-EDDIES[1]	☐-TORRENTIAL[-1]
☐ - 0.7-1m [4]	☐-POOL WIDTH = RIFFLE WIDTH [1]	☑-FAST[1]	☐-INTERSTITIAL[-1]
☐ - 0.4-0.7m [2]	☐-POOL WIDTH < RIFFLE W. [0]	☑-MODERATE [1]	☐-INTERMITTENT[-2]
☐ - 0.2- 0.4m [1]	☐-IMPOUNDED [-1]	☑-SLOW [1]	☑-VERY FAST[1]
☐ - < 0.2m [POOL=0]	COMMENTS: ______	☐-NONE [-1]	

Pool/ Current: **12** Max 12

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH	RUN DEPTH	RIFFLE/RUN SUBSTRATE	RIFFLE/RUN EMBEDDEDNESS
☑ - Best Areas >10 cm [2]	☑ - MAX > 50 [2]	☑STABLE (e.g.,Cobble, Boulder) [2]	☐ - NONE [2]
☐ - Best Areas 5-10 cm[1]	☐ - MAX < 50[1]	☐MOD. STABLE (e.g.,Large Gravel) [1]	☐ - LOW [1]
☐ - Best Areas < 5 cm		☐UNSTABLE (Fine Gravel,Sand) [0]	☑ - MODERATE [0]
☐ - NO RIFFLE [Metric=0]			☐ - EXTENSIVE [-1]

COMMENTS ______

Riffle/Run: **6** Max 8

Gradient: **4** Max 10

6] GRADIENT (ft/mi): 150 DRAINAGE AREA (sq.mi.) : ~123

%POOL: 40 %GLIDE: 20
%RIFFLE: 20 %RUN: 20

** Best areas must be large enough to support a population of riffle-obligate species

Modified 06/01/2005

[redacted]

Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 74

River Code: ______ **RM:** ______ **Stream:** LVR
Station ID: ______ **Location:** CAR001
Date: ______ **Scorer:** ______ **Latitude:** ______ **Longitude:** ______

1] SUBSTRATE (Check ONLY Two SubstrateTYPE BOXES; Estimate % present

TYPE POOL RIFFLE		TYPE POOL RIFFLE		SUBSTRATE ORIGIN	SUBSTRATE QUALITY
☐☐-BLDR /SLBS[10]	___ ___	☐☐-GRAVEL [7]	___ ___	Check ONE (OR 2 & AVERAGE)	Check ONE (OR 2 & AVERAGE)
☐☐-Lg BOULD. [10]	___ ___	☐☐-SAND [6]	___ ___	☒-LIMESTONE [1]	SILT: ☐-SILT HEAVY [-2]
☒☐-BOULDER [9]	___ ___	☐☐-BEDROCK[5]	___ ___	☐-TILLS [1]	☒-SILT MODERATE [-1]
☐☒-COBBLE [8]	___ ___	☐☐-DETRITUS[3]	___ ___	☐-WETLANDS[0]	☐-SILT NORMAL [0]
☐☐-HARDPAN [4]	___ ___	☐☐-ARTIFICIAL[0]	___ ___	☐-HARDPAN [0]	☐-SILT FREE [1]
☐☐-MUCK [2]	___ ___	☐☐-SILT [2]	___ ___	☐-SANDSTONE [0]	EMBEDDEDNESS: ☐-EXTENSIVE [-2]
				☐-RIP/RAP [0]	☒-MODERATE [-1]
NUMBER OF SUBSTRATE TYPES:	☒-4 or More [2]			☐-LACUSTRINE [0]	☐-NORMAL [0]
(High Quality Only, Score 5 or >)	☐-3 or Less [0]			☐-SHALE [-1]	☐-NONE [1]
				☐-COAL FINES [-2]	

COMMENTS: bedrock, cobble, gravel boulder present

Substrate: 18 — Max 20

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)

(Structure) **TYPE:** Score All That Occur

- 1 UNDERCUT BANKS [1]
- 1 OVERHANGING VEGETATION [1]
- 0 SHALLOWS (IN SLOW WATER) [1]
- 1 ROOTMATS [1]
- 0 POOLS> 70 cm [2]
- 0 ROOTWADS [1]
- 2 BOULDERS [1]
- 0 OXBOWS, BACKWATERS [1]
- 0 AQUATIC MACROPHYTES [1]
- 1 LOGS OR WOODY DEBRIS [1]

COMMENTS:

AMOUNT: (Check ONLY One or check 2 and AVERAGE)
- ☐- EXTENSIVE > 75% [11]
- ☒- MODERATE 25-75% [7]
- ☐- SPARSE 5-25% [3]
- ☐- NEARLY ABSENT < 5%[1]

Cover: 12 — Max 20

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐- HIGH [4]	☐- EXCELLENT [7]	☐- NONE [6]	☐- HIGH [3]	☐- SNAGGING	☐- IMPOUND.
☐- MODERATE [3]	☒- GOOD [5]	☐- RECOVERED [4]	☒- MODERATE [2]	☐- RELOCATION	☐- ISLANDS
☒- LOW [2]	☐- FAIR [3]	☒- RECOVERING [3]	☐- LOW [1]	☐- CANOPY REMOVAL	☐- LEVEED
☐- NONE [1]	☐- POOR [1]	☐- RECENT OR NO RECOVERY [1]		☐- DREDGING	☒- BANK SHAPING
		☐- IMPOUNDED [-1]		☒- ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: slag on right descending bank

Channel: 12 — Max 20

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH L R (Per Bank)	FLOOD PLAIN QUALITY (PAST 100 Meter RIPARIAN) L R (Most Predominant Per Bank)	L R	BANK EROSION L R (Per Bank)
☒☒- VERY WIDE > 100m [5]	☒☐-FOREST, SWAMP [3]	☐☐-CONSERVATION TILLAGE [1]	☒☒-NONE/LITTLE [3]
☐☐- WIDE > 50m [4]	☐☐-SHRUB OR OLD FIELD [2]	☐☐-URBAN OR INDUSTRIAL [0]	☐☐-MODERATE [2]
☐☐- MODERATE 10-50m [3]	☐☒-RESIDENTIAL, PARK, NEW FIELD [1]	☐☐-OPEN PASTURE, ROWCROP [0]	☐☐-HEAVY/SEVERE[1]
☐☐- NARROW 5-10 m [2]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐- VERY NARROW <5 m[1]			
☐☐- NONE [0]			

Comments:

Riparian: 10 — Max 10

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)	MORPHOLOGY (Check 1 or 2 & AVERAGE)	CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)	
☒- >1m [6]	☒-POOL WIDTH > RIFFLE WIDTH [2]	☐-EDDIES[1]	☐-TORRENTIAL[-1]
☐- 0.7-1m [4]	☐-POOL WIDTH = RIFFLE WIDTH [1]	☒-FAST[1]	☐-INTERSTITIAL[-1]
☐- 0.4-0.7m [2]	☐-POOL WIDTH < RIFFLE W. [0]	☒-MODERATE [1]	☐-INTERMITTENT[-2]
☐- 0.2-0.4m [1]	☐-IMPOUNDED [-1]	☒-SLOW [1]	☐-VERY FAST[1]
☐- < 0.2m [POOL=0]	COMMENTS:	☐-NONE [-1]	

Pool/Current: 11 — Max 12

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH	RUN DEPTH	RIFFLE/RUN SUBSTRATE	RIFFLE/RUN EMBEDDEDNESS
☒- Best Areas >10 cm [2]	☒- MAX > 50 [2]	☒-STABLE (e.g.,Cobble, Boulder) [2]	☐- NONE [2]
☐- Best Areas 5-10 cm[1]	☐- MAX < 50[1]	☐-MOD. STABLE (e.g.,Large Gravel) [1]	☒- LOW [1]
☐- Best Areas < 5 cm		☐-UNSTABLE (Fine Gravel,Sand) [0]	☐- MODERATE [0]
☐- NO RIFFLE [Metric=0]			☐- EXTENSIVE [-1]

COMMENTS

Riffle/Run: 7 — Max 8

Gradient: 4 — Max 10

6] GRADIENT (ft/mi): 38 DRAINAGE AREA (sq.mi.) : ~124

%POOL: 40 %GLIDE: 15
%RIFFLE: 30 %RUN: 15

*' Best areas must be large enough to support a population of riffle-obligate species

Modified 06/01/2005

APPENDIX C

Illinois Department of Natural Resources Scientific Permit

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Authorization is hereby granted, under Section 5/3.22, Chapter 520 and Section 5/20-100, Chapter 515 of the Illinois compliled Statues to:

Last Name: **Cheek** First Name: **Terry** Permit Number: **A09.5195**

Issued: **4/16/2009** **Expires: 12/31/2009**

Business Name: Geosyntec Consultants

Street Address: 1255 Roberts Blvd NW, Suite 200

City: Kennesaw State: GA Zip Code: 30144

for strictly scientific, educational or zoological purposes, to take the Illinois fauna identified below subject to the following provisions:

May legally capture, by scientifically accepted methods, only the specific aquatic species listed on the accompanying Illinois Department of Natural Resources (IDNR) scientific permit application/project proposal (on file in Springfield, IL.) strictly for scientific, educational, and/or zoological purposes (except endangered and threatened species). After data has been humanely collected from these species, all animals shall be released unharmed at or near the original site of capture. Deceased animals and/or animal parts must be buried or given to a public or state scientific educational or zoological institution. A federal permit is required for all projects involving federally regulated species. If endangered and threatened species are taken, the IDNR Division of Natural Heritage, Endangered Species Coordinator must be notified. The Endangered Species Coordinator must approve of the disposition of specimens.
Authorization: Statewide, exclusive of nature preserves, and IDNR owned and managed properties.
Individuals working under direction of applicant include: Andy Whorton, Stacy Shinneman, Richard Clausen, Ben Deetsch, Brian O'Neill, Caroline Doksansky, Tom Wurzinger

I agree to the following provisions and terms of this Scientific Permit.

Permittee's Signature: Terry E. Cheek
(Permit not valid unless signed)

Approved By: Mike Conlin Date: 4.16.09
Office of Resource Conservation

TERMS FOR SCIENTIFIC PERMIT

1. Under no circumstances shall a scientific permit be used in lieu of sport or commercial licenses.
2. All taking shall be performed by or under the direct supervision of the permittee. Permitte must be present with persons involved in actual taking.
3. All gear left unattended must be tagged bearing name and scientific permit number of permittee.
4. Permittee must be at least eighteen (18) years of age.
5. Permits are not transferable and PERMITTE SHALL CARRY PERMIT AT ALL TIMES WHEN TAKING FAUNA.
6. Agency, company or institution listed on the application is responsible for the taking activities and reports of the individual issued this permit
7. Scientific permits will not be valid for taking any species appearing on official State List of Endangered and Threatened Vertebrate Species of Illinois (see attached Administrative Rule, Part 1010) without specific written approval from the Department of Natural Resources.
8. A federal Permit is required for the taking of species protected by the Federal Government in addition to the State Scientific Permit.
9. The Division of Wildlife Resources may require special conditions or provsions on any Scientific Permit.
10. Use of rotenone or any other toxic materials for taking must have special written approval from the Department of Natural Resources and may need a variance from the Illinois Environmental Protection Agency.
11. By january 31 of next year, an annual report of the permittee's activies must be submitted to the Division of Wildlife Resources. In addition, the permittee shall submit a copy of all written reports, etc. that result from the permitted activity. Permits will be renewed after these annual reports and appropriate publications have been received.
12. Any permit may be revoked or suspended at any time by the Department of Natural Resources.
13. Permits expire December 31 each calendar year unless otherwise specified.

APPENDIX D

Laboratory Sample Data of Benthic Macroinvertebrates from Pennington & Associates, Inc.

Pennington & Associates - Raw Dataset (no data reduction) - Little Vermilion River, August 11-13, 2009.

SPECIES	T.V.	F.F.G.	CL	CAR-004	CAR-004	CAR-003	CAR-003	CAR-002	CAR-002	CRT-001	CRT-001
				LB	RB	LB	RB	LB	RB	LB	RB
				East	West	East	West	East	West	East	West
PLATYHELMINTHES											
Turbellaria											
Tricladida											
Dugesiidae	5	CG									
Girardia (Dugesia) tigrina	5	CG					1				1
MOLLUSCA											
Bivalvia											
Veneroida											
Corbiculidae											
Corbicula fluminea	6.1	CF									1
Sphaeriidae											
Sphaerium sp.	7.6	CF		3	1		1				
Gastropoda											
Mesogastropoda											
Pleuroceridae				2							
Elimia sp.	2.5	SC					1				
Basommatophora											
Ancylidae											
Lymnaeidae											
Fossaria sp.	7	SC		1	1		1				3
Physidae											
Physella sp.	**8.8**	SC		16	8	1					2
ANNELIDA											
Oligochaeta											
Tubificida											
Enchytraeidae		CG					1				
Tubificidae w.o.h.c.	9	CG			3			1	1		1
ARTHROPODA											
Crustacea											
Cladocera											
Daphnidae											
Ceriodaphnia sp.								6			
Isopoda											
Asellidae											
Caecidotea sp.	9.1	CG		11	1	1	12	7		10	2
Decapoda											
Cambaridae											
Orconectes sp.	5.5	CG		2	4		2				
Insecta											
Ephemeroptera											
Baetidae	5	CG									
Baetis sp.	5.4	CG		14	8	44			2		
Baetis flavistriga	6.6.	CG		24	35	38	5	4	2	3	
Baetis intercalaris	5	CG		1	2	9		1			
Pseudocloeon sp.	4	CG			2						
Heptageniidae	3.2	SC	CL	2			7				
Leucrocuta sp.	2.4	SC	CL	1	4	1					
Maccaffertium (Stenonema) sp.	4.1	SC	CL	2	19	20					
Maccaffertium (Stenonema) mediopunctatum	3.8	SC	CL	1	3		1				
Stenacron interpunctatum	6.9	CG	CL		3	1	1				
Isonychiidae											
Isonychia sp.	3.5	CF		1		8	4		1		
Tricorythidae											
Tricorythodes sp.	5.1	CG		20	17	12	15	1	7		
Odonata											
Aeshnidae											
Boyeria vinosa	5.9	PR		2		1	2	1		1	
Calopterygidae								24			1
Calopteryx sp.	7.8	PR						4		5	
Hetaerina titia	5.6	PR		4	4						
Hetaerina sp.	5.6	PR				2	2	1	11		3
Coenagrionidae											
Argia sp.	8.2	PR						2			1

SPECIES	T.V.	F.F.G.	CL	CAR-004	CAR-004	CAR-003	CAR-003	CAR-002	CAR-002	CRT-001	CRT-001
				LB	RB	LB	RB	LB	RB	LB	RB
				East	West	East	West	East	West	East	West
Ischnura sp.	9.5	PR						1			1
Gomphidae								1			
Libellulidae											1
Macromia sp.	6.2	PR					1	1			
Hemiptera											
Corixidae	9.1	PH			2		2	2	6	1	16
Veliidae											
Microvelia sp.	9	PR		3	1	1					3
Rhagovelia obesa	9	PR					1	1			2
Megaloptera											
Corydalidae											
Corydalus cornutus	5.2	PR	CL		1	4	2		1	1	4
Sialidae											
Sialis sp.	7.2	PR									2
Trichoptera											
Hydropsychidae	4	CF	CL								10
Ceratopsyche morosa	3.2	CF	CL	63	61	41	40	15	50	52	35
Cheumatopsyche sp.	6.2	CF	CL	10	17	54	67	8	65	48	72
Hydropsyche sp.	4	CF	CL	10	7	108	17	15	37	35	53
Hydropsyche betteni gp.	7.8	CF	CL	2	1	4	2		13	16	5
Hydroptilidae											
Hydroptila sp.	6.2	PH	CL	6	14	42	23	7	22	7	11
Leptoceridae							1				
Nectopsyche diarina	2.9	PR			2	1		2			1
Nectopsyche sp.	2.9	PR					2	1			
Oecetis avara						2	1		1	3	1
Oecetis sp.	4.7	PR		2			2	1			
Polycentropodidae									5		
Neureclipsis sp.	4.2	CF	CL				4	2	2	3	9
Polycentropus sp.	3.5	PR	CL			9			1		
Uenoidae											
Neophylax sp.	2.2	SC	CL								
Lepidoptera											
Pyralidae											
Petrophila sp.	1.8	SH	CL	2	1	8			1		
Coleoptera											
Dryopidae											
Helichus sp.	4.6	SC	CL	1			2				
Dytiscidae											
Laccophilus sp.	10	PR			1						
Elmidae				4					1		2
Ancyronyx variegata	6.5	SC	CL		1		1				1
Dubiraphia sp.	5	SC	CL					6		1	
Dubiraphia vittata	4.1	SC	CL	12	6	5	9	62	6	22	25
Macronychus glabratus	4.6	CG	CL	5	1	12	3	2		10	3
Optioservus sp.	2.4	SC	CL	1		2					
Stenelmis sp.	5.1	SC	CL	23	7	24	22	18	12	10	9
Gyrinidae											
Gyrinus sp.	6.2	PR		1	2						
Limnichidae											
Lutrochus sp.						1					
Psephenidae											
Ectopria sp.	4.2	SC	CL	1							
Diptera											
Chironomidae											
Ablabesmyia mallochi	7.2	PR					2	4			2
Ablabesmyia rhamphe gp.	7.5	PR						1			
Brillia flavifrons	5.2	SH				3	1	1	1	3	
Cardiocladius obscurus	6.2	PR	CL			28	12	23	10	73	51
Chironomus sp.	9.6	CG					1	3		1	
Cladopelma sp.	3.5	CG									
Cladotanytarsus sp.	4.1	CG			1			3			
Conchapelopia sp.	8.7	PR		4	4	6	14	15	6	2	6
Cricotopus sp.	7	SH		3	15	3	6	19	3	13	17
Cricotopus bicinctus	8.5	SH		6	9	5	2	6			5

SPECIES	T.V.	F.F.G.	CL	CAR-004	CAR-004	CAR-003	CAR-003	CAR-002	CAR-002	CRT-001	CRT-001
				LB	RB	LB	RB	LB	RB	LB	RB
				East	West	East	West	East	West	East	West
Cricotopus trifascia	7	SH				2					1
Cryptochironomus sp.	6.4	CG			1		1				
Diamesa sp.	8.1	CG								1	
Dicrotendipes neomodestus	8.1	CG			5	1		1			1
Eukiefferiella claripennis gp.	5.6	CG			2						
Microtendipes pedellus gp.	6.2	CF		3	6		2	8	1	1	2
Nanocladius distinctus	7.2	CG						4			1
Nilotanypus sp.	3.9	PR		2							
Nilothauma sp.	5	CG				1			3		8
Orthocladius sp.	7.3	CG				1				1	
Paracladopelma sp.	5.5	CG			1						5
Parakiefferiella sp.	5.4	CG		2	3			8		1	
Parametriocnemus sp.	3.7	CG			1		2				
Phaenopsectra punctipes gp.	6	SC									1
Polypedilum flavum (convictum)				27	10	10	16	4	9	1	7
Polypedilum fallax	6.4	SH			1	1	1	3		1	
Polypedilum illinoense	9	SH			7	17	5	5	8	3	10
Polypedilum sp.	6.8	SH		2							
Rheocricotopus robacki	7.3	CG		2	1		1				
Rheotanytartsus exiguus gp.	6.4	CF		24	24	5	6	1	3		
Stenochironomus sp.	6.5	CG			1	1		3	3	7	1
Tanytarsus sp.	6.7	CG			4		2	3			
Thienemanniella xena	5.9	CG		2							
Tribelos jucundum	6.3	CG			4	1		6	3	2	8
Tvetenia paucunca											1
Zavrelimyia sp.	9.1	PR									1
Empididae											
Hemerodromia sp.	8.1	PR		1		1	2	4	2	5	2
Ephydridae	9	SH									1
Simuliidae										3	
Simulium sp.	4	CF		5	12	23	10		21	11	24
Tabanidae											
Chrysops sp.	6.7	PR		2	3						
Tipulidae											
Limonia sp.	9.6	SC				1					
Tipula sp.	7.3	SH								1	1
TOTAL NO. OF ORGANISMS				**338**	**355**	**566**	**344**	**322**	**320**	**358**	**437**
TOTAL NO. OF TAXA				**47**	**53**	**46**	**52**	**49**	**34**	**35**	**52**

Pennington & Associates - Raw Dataset (reflecting data reduction) - Little Vermilion River, August 11-13, 2009.

SPECIES	T.V.	F.F.G.	CL	CAR-004	CAR-004	CAR-003	CAR-003	CAR-002	CAR-002	CAR-001	CAR-001
				LB	RB	LB	RB	LB	RB	LB	RB
				East	West	East	West	East	West	East	West
PLATYHELMINTHES											
Turbellaria											
Tricladida											
Dugesiidae	5	CG									
Girardia (Dugesia) tigrina	5	CG					1				
MOLLUSCA											
Bivalvia											
Veneroida											
Corbiculidae											
Corbicula fluminea	6.1	CF									1
Sphaeriidae											
Sphaerium sp.	7.6	CF		3	1		1				
Gastropoda											
Mesogastropoda											
Pleuroceridae				2							
Elimia sp.	2.5	SC					1				
Basommatophora											
Ancylidae											
Lymnaeidae											
Fossaria sp.	7	SC		1	1		1				1
Physidae											
Physella sp.	**8.8**	SC		16	8	1					2
ANNELIDA											
Oligochaeta											
Tubificida											
Enchytraeidae		CG					1				
Tubificidae w.o.h.c.	9	CG			3			1	1		1
ARTHROPODA											
Crustacea											
Cladocera											
Daphnidae											
Ceriodaphnia sp.								6			
Isopoda											
Asellidae											
Caecidotea sp.	9.1	CG		11	1		12	7		10	2
Decapoda											
Cambaridae											
Orconectes sp.	5.5	CG		2	4		2				
Insecta											
Ephemeroptera											
Baetidae	5	CG									
Baetis sp.	5.4	CG		14	8	21			2		
Baetis flavistriga	6.6.	CG		24	35	25	5	4	2	3	
Baetis intercalaris	5	CG		1	2	6		1			
Pseudocloeon sp.	4	CG			2						
Heptageniidae	3.2	SC	CL	2			7				
Leucrocuta sp.	2.4	SC	CL	1	4						
Maccaffertium (Stenonema) sp.	4.1	SC	CL	2	19	10					
Maccaffertium (Stenonema) mediopunctatum	3.8	SC	CL	1	3		1				
Stenacron interpunctatum	6.9	CG	CL		3	1	1				
Isonychiidae											
Isonychia sp.	3.5	CF		1		6	4		1		
Tricorythidae											
Tricorythodes sp.	5.1	CG		20	17	1	15	1	7		
Odonata											
Aeshnidae											
Boyeria vinosa	5.9	PR		2		1	2	1		1	
Calopterygidae								24			1
Calopteryx sp.	7.8	PR						4		5	
Hetaerina titia	5.6	PR		4	4						
Hetaerina sp.	5.6	PR				1	2	1	11		2
Coenagrionidae											
Argia sp.	8.2	PR						2			1
Ischnura sp.	9.5	PR						1			1
Gomphidae								1			
Libellulidae											
Macromia sp.	6.2	PR					1	1			

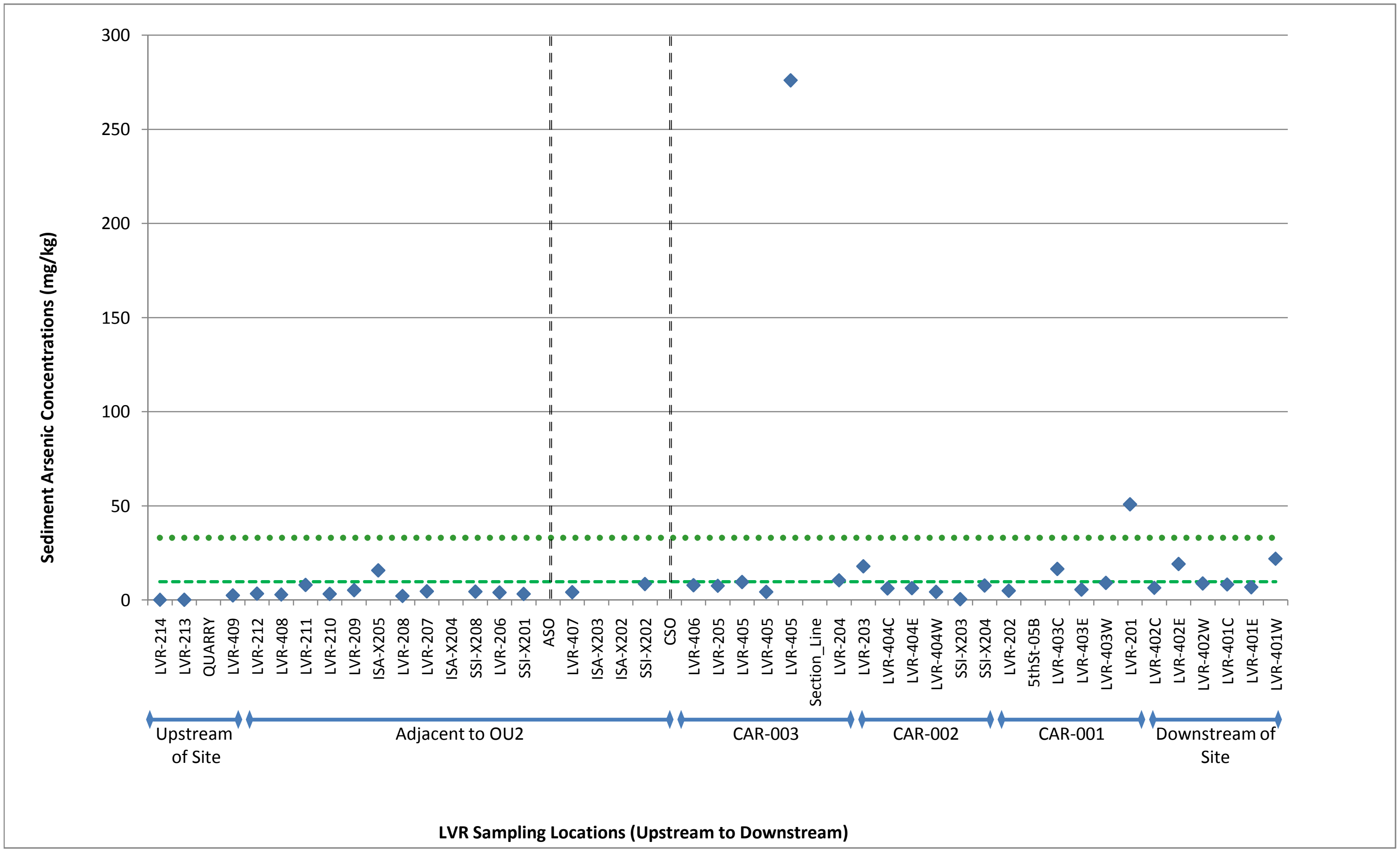
SPECIES	T.V.	F.F.G.	CL	CAR-004	CAR-004	CAR-003	CAR-003	CAR-002	CAR-002	CAR-001	CAR-001
				LB	RB	LB	RB	LB	RB	LB	RB
				East	West	East	West	East	West	East	West
Hemiptera											
Corixidae	9.1	PH			2		2	2	6	1	14
Veliidae											
Microvelia sp.	9	PR		3	1	1					2
Rhagovelia obesa	9	PR					1	1			2
Megaloptera											
Corydalidae											
Corydalus cornutus	5.2	PR	CL		1	3	2		1	1	2
Sialidae											
Sialis sp.	7.2	PR									1
Trichoptera											
Hydropsychidae	4	CF	CL								10
Ceratopsyche morosa	3.2	CF	CL	63	61	23	40	15	50	52	21
Cheumatopsyche sp.	6.2	CF	CL	10	17	31	67	8	65	48	50
Hydropsyche sp.	4	CF	CL	10	7	53	17	15	37	35	33
Hydropsyche betteni gp.	7.8	CF	CL	2	1		2		13	16	5
Hydroptilidae											
Hydroptila sp.	6.2	PH	CL	6	14	26	23	7	22	7	10
Leptoceridae							1				
Nectopsyche diarina	2.9	PR			2	1		2			1
Nectopsyche sp.	2.9	PR					2	1			
Oecetis avara						2	1		1	3	1
Oecetis sp.	4.7	PR		2			2	1			
Polycentropodidae									5		
Neureclipsis sp.	4.2	CF	CL				4	2	2	3	8
Polycentropus sp.	3.5	PR	CL			5			1		
Uenoidae											
Neophylax sp.	2.2	SC	CL								
Lepidoptera											
Pyralidae											
Petrophila sp.	1.8	SH	CL	2	1	7			1		
Coleoptera											
Dryopidae											
Helichus sp.	4.6	SC	CL	1			2				
Dytiscidae											
Laccophilus sp.	10	PR			1						
Elmidae				4					1		
Ancyronyx variegata	6.5	SC	CL		1		1				1
Dubiraphia sp.	5	SC	CL					6		1	
Dubiraphia vittata	4.1	SC	CL	12	6	3	9	62	6	22	18
Macronychus glabratus	4.6	CG	CL	5	1	6	3	2		10	1
Optioservus sp.	2.4	SC	CL	1		2					
Stenelmis sp.	5.1	SC	CL	23	7	16	22	18	12	10	6
Gyrinidae											
Gyrinus sp.	6.2	PR		1	2						
Limnichidae											
Lutrochus sp.						1					
Psephenidae											
Ectopria sp.	4.2	SC	CL	1							
Diptera											
Chironomidae											
Ablabesmyia mallochi	7.2	PR					2	4			2
Ablabesmyia rhamphe gp.	7.5	PR						1			
Brillia flavifrons	5.2	SH				3	1	1	1	3	
Cardiocladius obscurus	6.2	PR	CL			17	12	23	10	73	41
Chironomus sp.	9.6	CG					1	3		1	
Cladopelma sp.	3.5	CG									
Cladotanytarsus sp.	4.1	CG			1			3			
Conchapelopia sp.	8.7	PR		4	4	3	14	15	6	2	5
Cricotopus sp.	7	SH		3	15	3	6	19	3	13	11
Cricotopus bicinctus	8.5	SH		6	9	2	2	6			5
Cricotopus trifascia	7	SH				1					1
Cryptochironomus sp.	6.4	CG			1		1				
Diamesa sp.	8.1	CG								1	
Dicrotendipes neomodestus	8.1	CG			5	1		1			1
Eukiefferiella claripennis gp.	5.6	CG			2						
Microtendipes pedellus gp.	6.2	CF		3	6		2	8	1	1	2
Nanocladius distinctus	7.2	CG						4			1
Nilotanypus sp.	3.9	PR		2							

SPECIES	T.V.	F.F.G.	CL	CAR-004	CAR-004	CAR-003	CAR-003	CAR-002	CAR-002	CAR-001	CAR-001
				LB	RB	LB	RB	LB	RB	LB	RB
				East	West	East	West	East	West	East	West
Nilothauma sp.	5	CG				1			3		7
Orthocladius sp.	7.3	CG				1				1	
Paracladopelma sp.	5.5	CG			1						4
Parakiefferiella sp.	5.4	CG		2	3			8		1	
Parametriocnemus sp.	3.7	CG			1		2				
Phaenopsectra punctipes gp.	6	SC									1
Polypedilum flavum (convictum)				27	10	7	16	4	9	1	5
Polypedilum fallax	6.4	SH			1		1	3		1	
Polypedilum illinoense	9	SH			7	12	5	5	8	3	8
Polypedilum sp.	6.8	SH		2							
Rheocricotopus robacki	7.3	CG		2	1		1				
Rheotanytartsus exiguus gp.	6.4	CF		24	24	3	6	1	3		
Stenochironomus sp.	6.5	CG			1			3	3	7	1
Tanytarsus sp.	6.7	CG			4		2	3			
Thienemanniella xena	5.9	CG		2							
Tribelos jucundum	6.3	CG			4	1		6	3	2	6
Tvetenia paucunca											1
Zavrelimyia sp.	9.1	PR									1
Empididae											
Hemerodromia sp.	8.1	PR		1		1	2	4	2	5	2
Ephydridae	9	SH									1
Simuliidae										3	
Simulium sp.	4	CF		5	12	14	10		21	11	17
Tabanidae											
Chrysops sp.	6.7	PR		2	3						
Tipulidae											
Limonia sp.	9.6	SC									
Tipula sp.	7.3	SH								1	1
TOTAL NO. OF ORGANISMS				**338**	**355**	**323**	**344**	**322**	**320**	**358**	**322**
TOTAL NO. OF TAXA				**47**	**53**	**40**	**52**	**49**	**34**	**35**	**49**

APPENDIX E

Upstream to Downstream Sediment COPEC Concentrations

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Arsenic
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

Sediment Arsenic Concentrations - mg/kg

Probable Effects Concentration - 33 mg/kg (MacDonald et al., 2000)

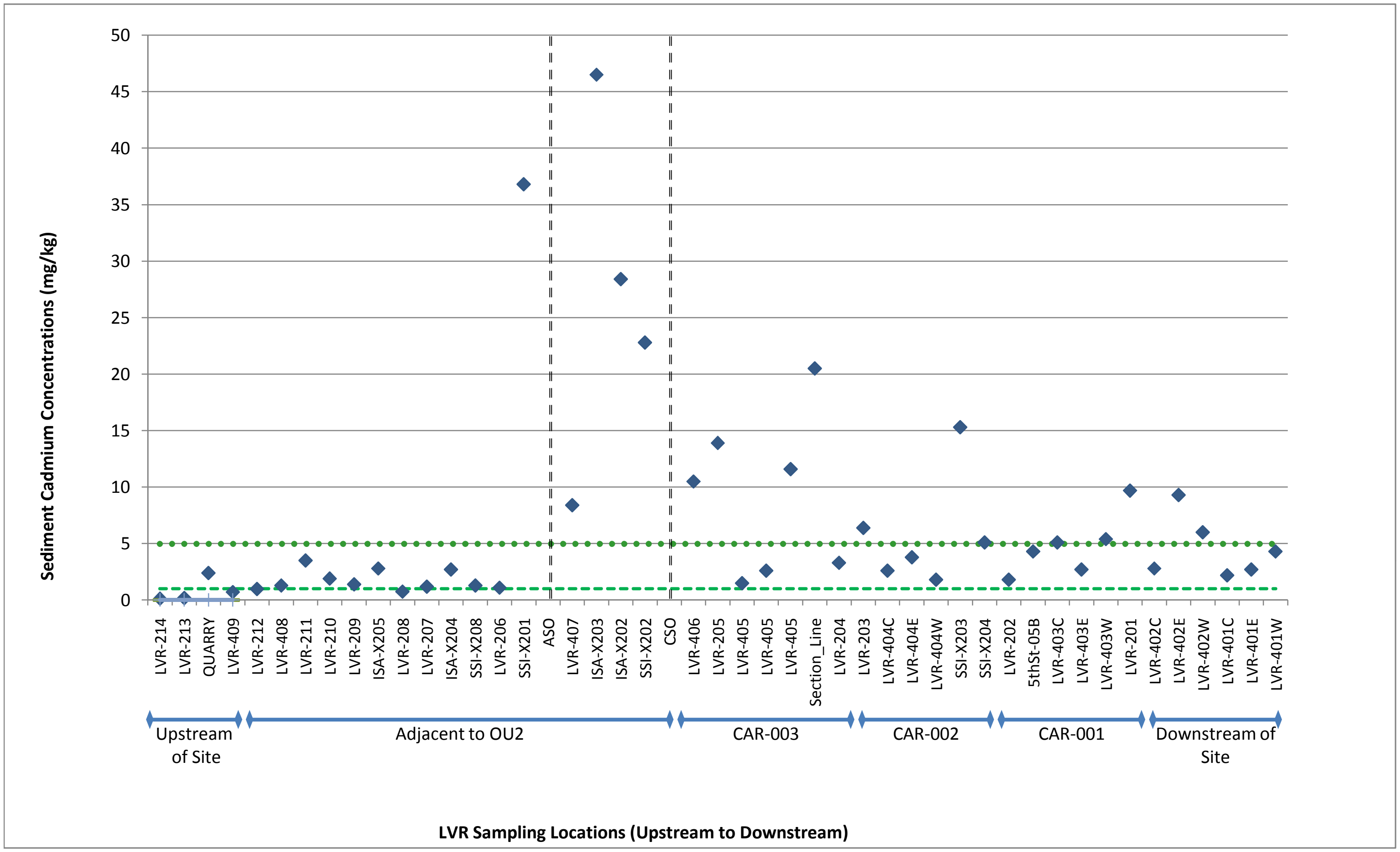
--- Threshold Effects Concentration - 9.79 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Cadmium
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

Sediment Cadmium Concentrations - mg/kg

Probable Effects Concentration - 4.98 mg/kg (MacDonald et al., 2000)

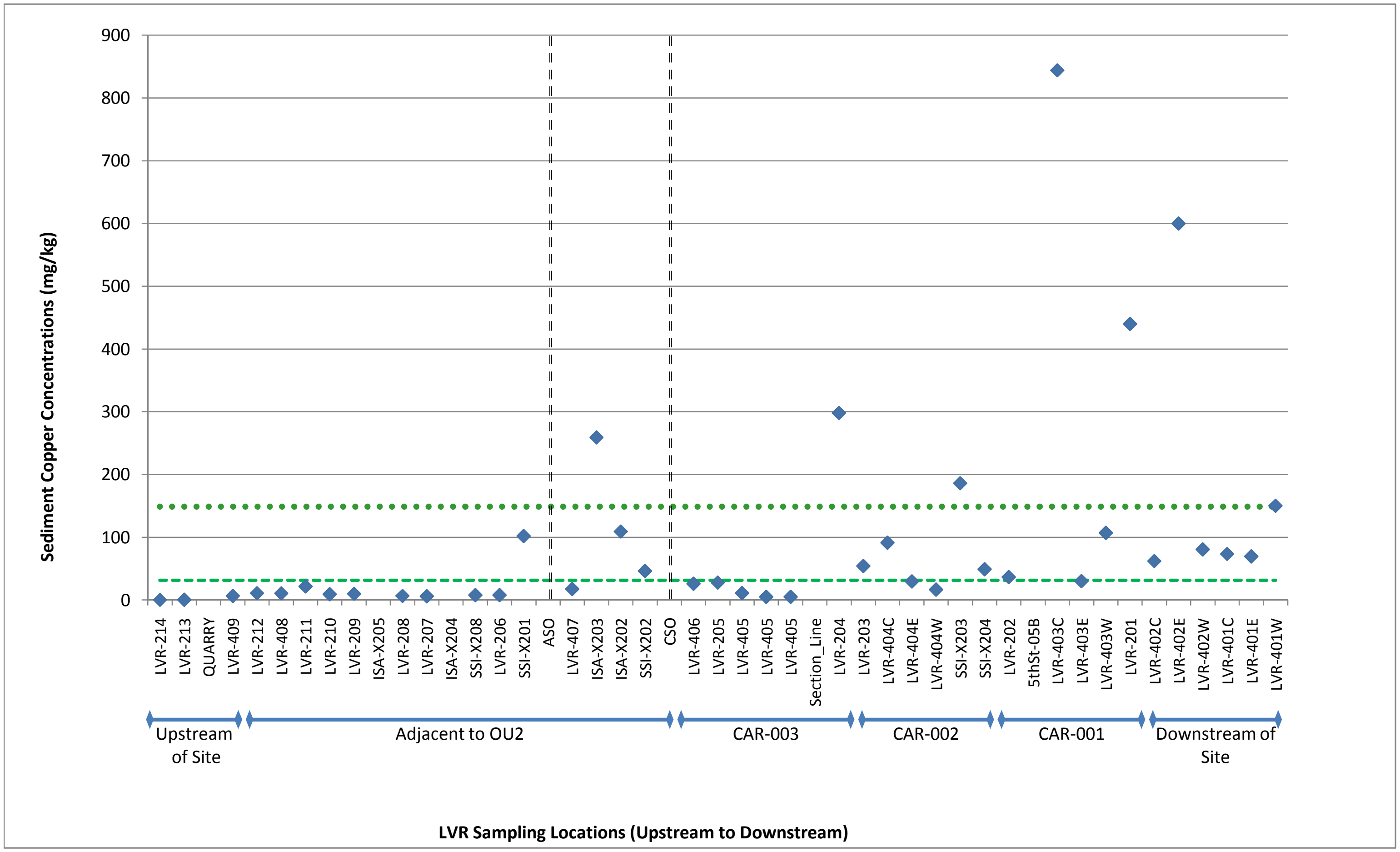
Threshold Effects Concentration - 0.99 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Copper
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

▲ Sediment Copper Concentrations - mg/kg

••• Probable Effects Concentration - 149 mg/kg (MacDonald et al., 2000)

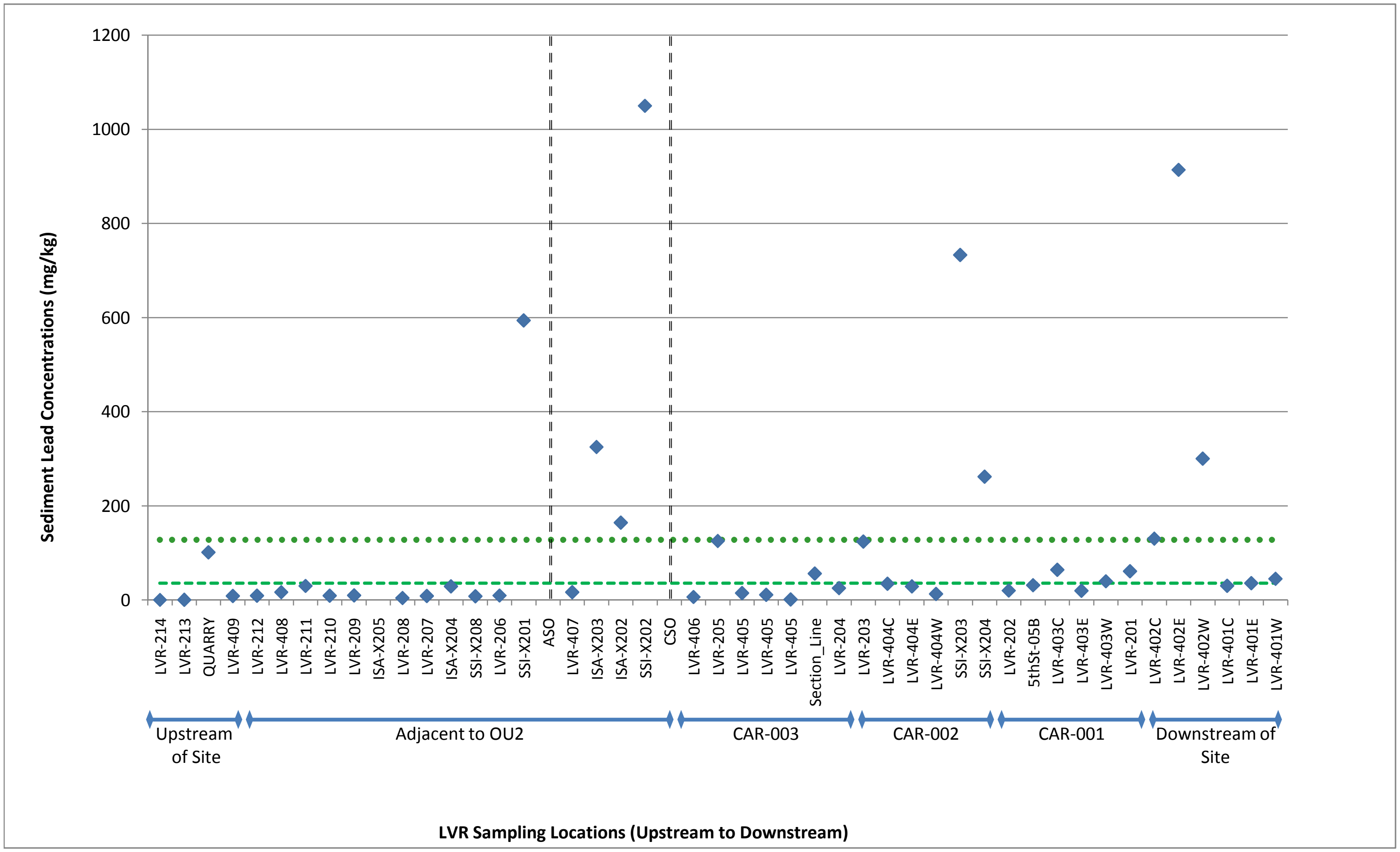
--- Threshold Effects Concentration - 31.6 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Lead
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

Sediment Lead Concentrations - mg/kg

Probable Effects Concentration - 128 mg/kg (MacDonald et al., 2000)

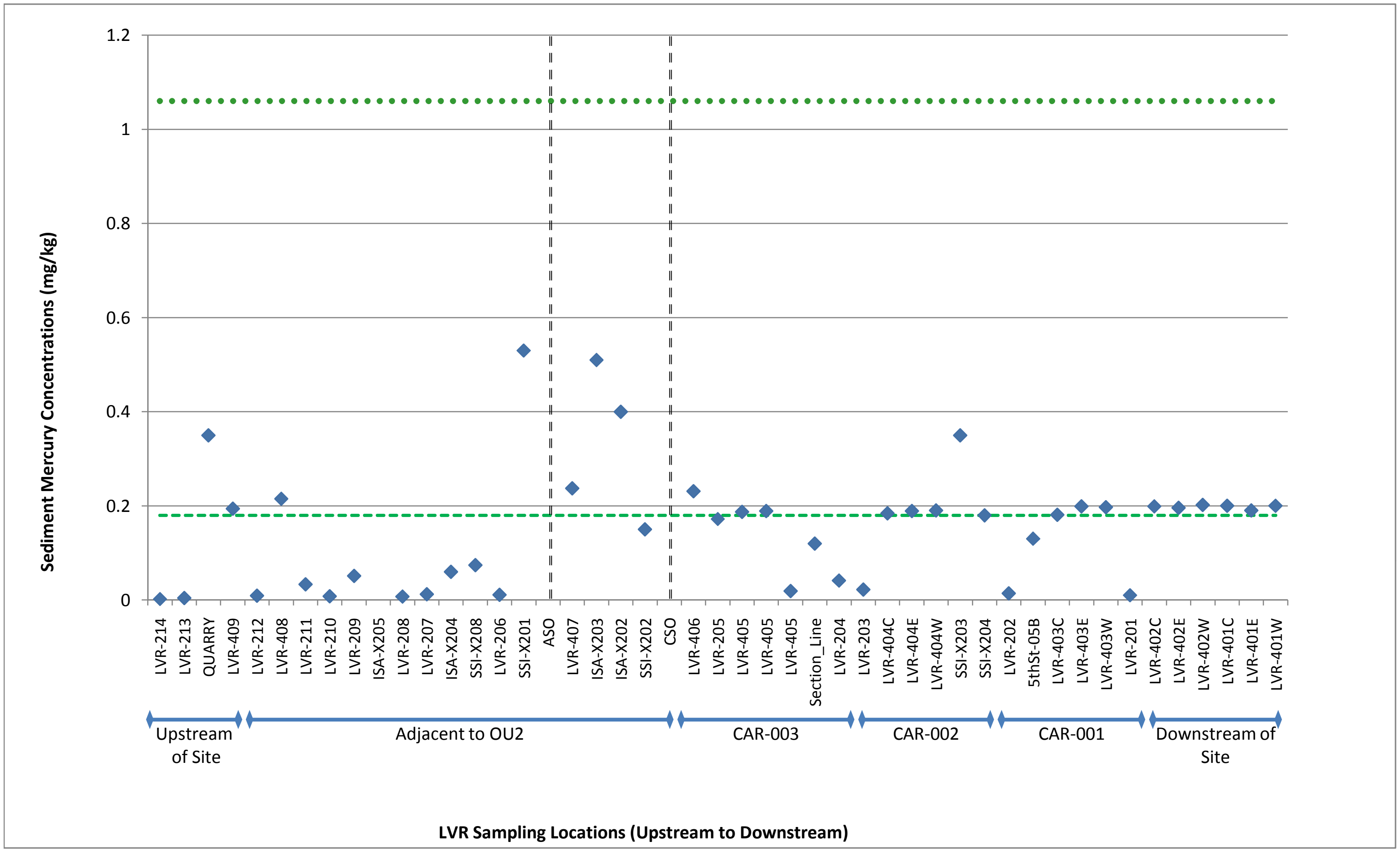
--- Threshold Effects Concentration - 35.8 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Mercury
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

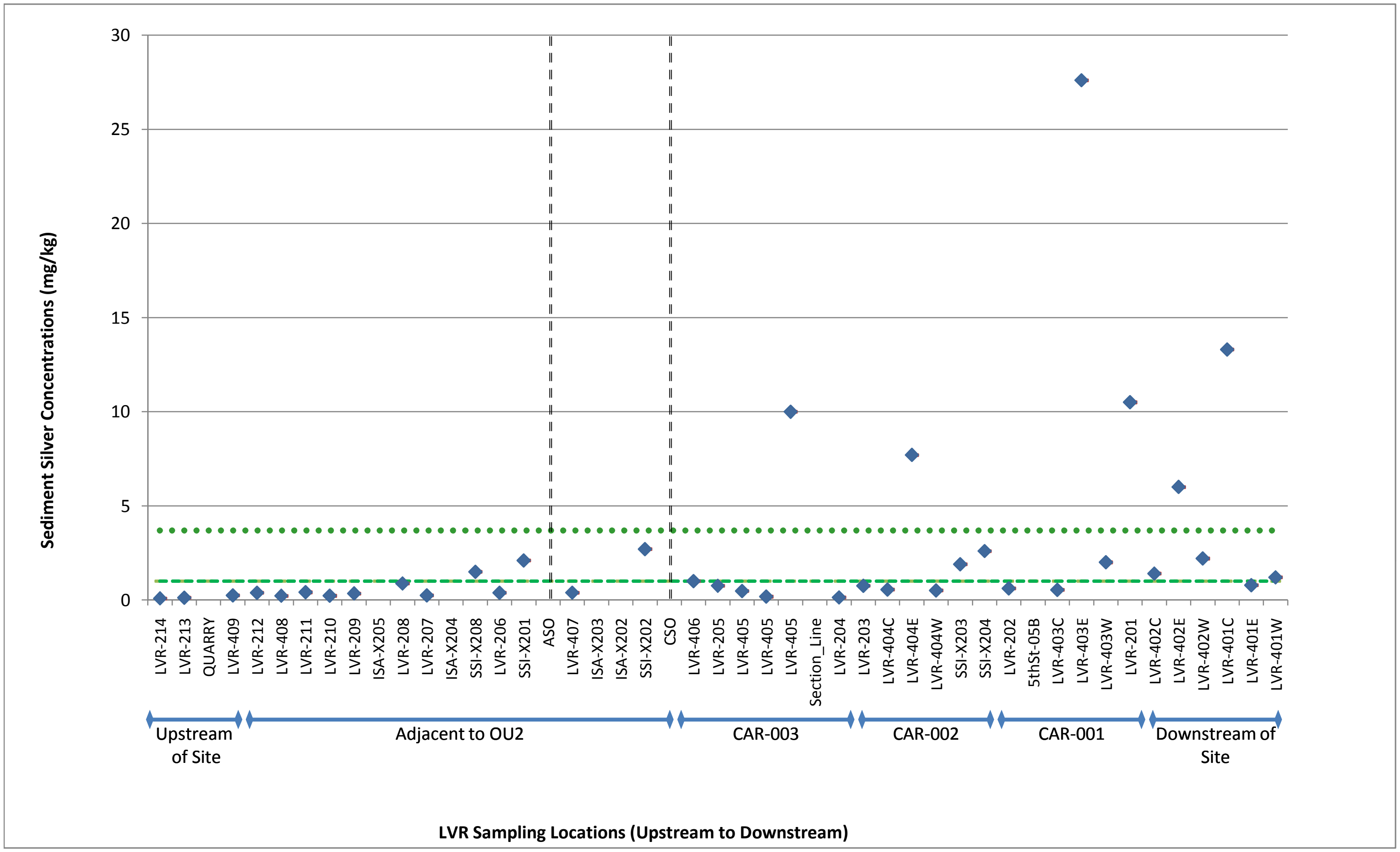
- Sediment Mercury Concentrations - mg/kg
- Probable Effects Concentration - 1.06 mg/kg (MacDonald et al., 2000)
- Threshold Effects Concentration - 0.18 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Silver
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

Sediment Silver Concentrations - mg/kg

Effects Range Median - 3.7 mg/kg (NOAA SQuiRT, 2008)

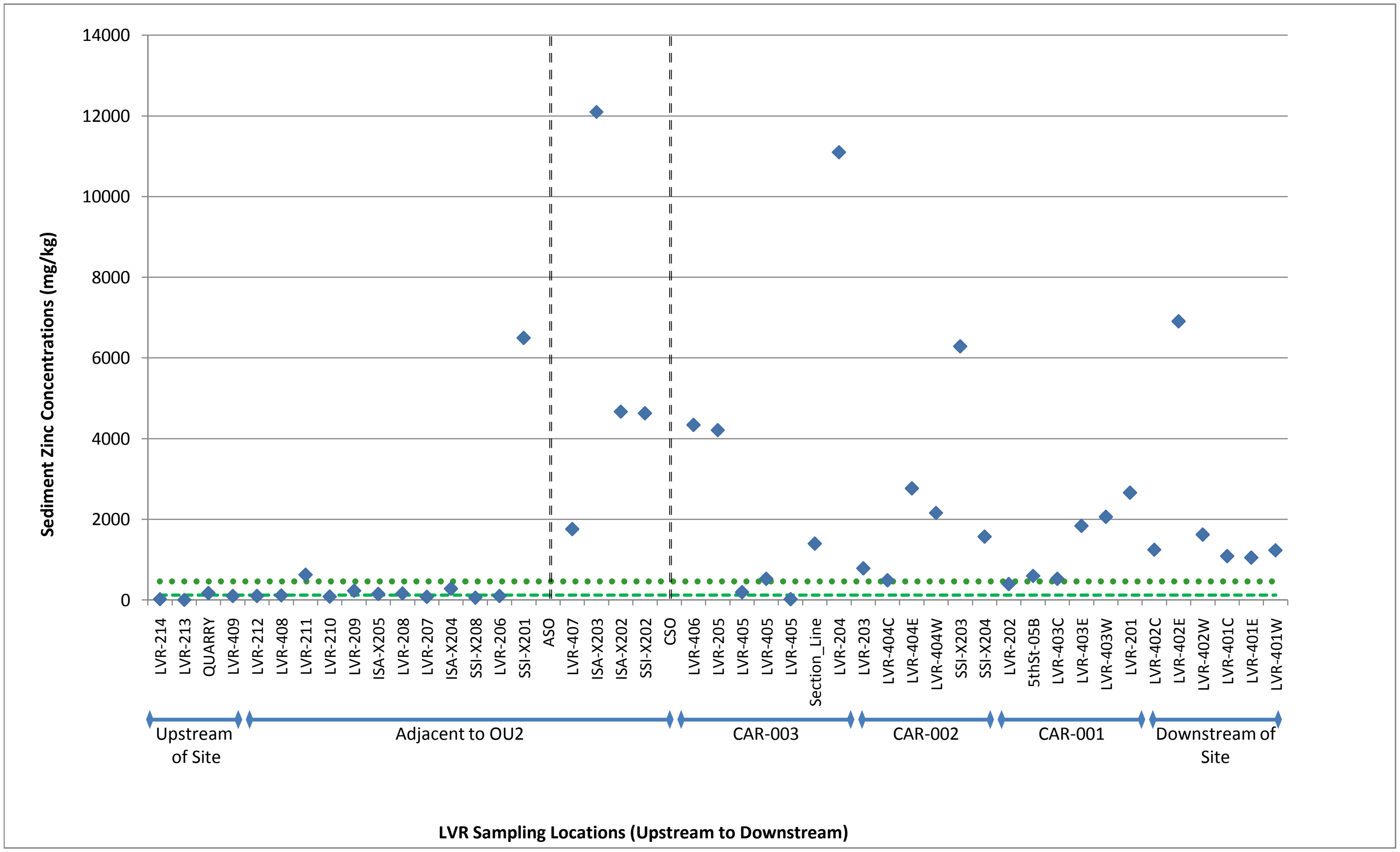
--- Threshold Effects Concentration - 0.5 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow

ATTACHMENT E
Upstream to Downstream Sediment COPEC Concentrations
Little Vermilion River Sediment - Zinc
Matthiessen and Hegeler Zinc Company Site - LaSalle, Illinois



Legend

- Sediment Zinc Concentrations - mg/kg
- Probable Effects Concentration - 459 mg/kg (MacDonald et al., 2000)
- Threshold Effects Concentration - 121 mg/kg (MacDonald et al., 2000)

COPEC = Constituent of Potential Ecological Concern

ASO = Abandoned Sewer Outfall

CSO = Combined Sewer Overflow